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Woods Hole Oceanographic Institution



SUMMARY OF THE GEOLOGIC DIVES
CONDUCTED IN THE GULF OF MAINE
DURING 1971 AND 1972 BY THE
RESEARCH SUBMERSIBLE ALVIN

By
Robert D. Ballard

MAY 1974

TECHNICAL REPORT

*Prepared for the Office of Naval Research
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Woods Hole, Massachusetts 02543

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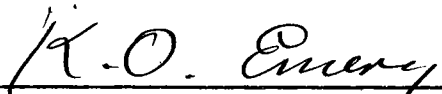
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K. O. Emery, Acting Chairman
Department of Geology & Geophysics

Introduction

In 1970 a comprehensive geological investigation of the Gulf of Maine was initiated by Robert D. Ballard and Elazar Urbizu Uchupi of the Woods Hole Oceanographic Institution. The purpose of the study was to better understand the tectonic evolution of the Gulf and in particular the behavior of the continental margin during the separation of the North American and African continents approximately 200 million years ago (Ballard, in preparation; Ballard and Uchupi, 1972).

The study itself centered around the use of three basic data collecting techniques; seismic reflection profiling, seismic refraction stations, and direct sampling. Between 1970 and 1973 ten cruises were made into the Gulf of Maine during which over 7,500 km of seismic reflection profiles were collected and over 100 refraction stations made. Based upon these profiles and refraction stations as well as similar published and unpublished information (Ballard, in preparation), a tectonic map was constructed for the Gulf and surrounding land masses. Using this map it was then possible to determine the location of sites where rock units crop out. Between July 1971 and August 1972 the research submersible ALVIN (figure 1) conducted a series of dives within the Gulf to locate and sample many of these outcrops. The purpose of this report is to document the results of this sampling program.

Sampling Procedure

The normal operating procedure for ALVIN and its surface support ship LULU was to proceed to the region where seismic reflection profiles indicated that the bedrock surface cropped out on the sea floor. Once in the area, an echo sounding survey was conducted to locate steep slopes and isolated pinnacles. At these locations radar buoys were implaced and the final dive site selected. Since currents in excess of 1/2 knot were common, the surface ship would stop its forward progress and estimate its current and wind drift. Based upon this estimate and the location and depth of the dive site, the surface ship would, then, place itself in such a position that by the time the launch procedure was completed and the submersible sank to the sea floor, ALVIN would land near the surveyed outcrop. This procedure worked well and the submersible commonly acquired the outcrop within 15 minutes of landing. A major improvement in the overall procedure would be the use of a small high resolution seismic profiling system to conduct the search instead of the 12 kHz echo sounder. Sediment cover over the bedrock surface accounted for a large percentage of unsuccessful sampling dives.

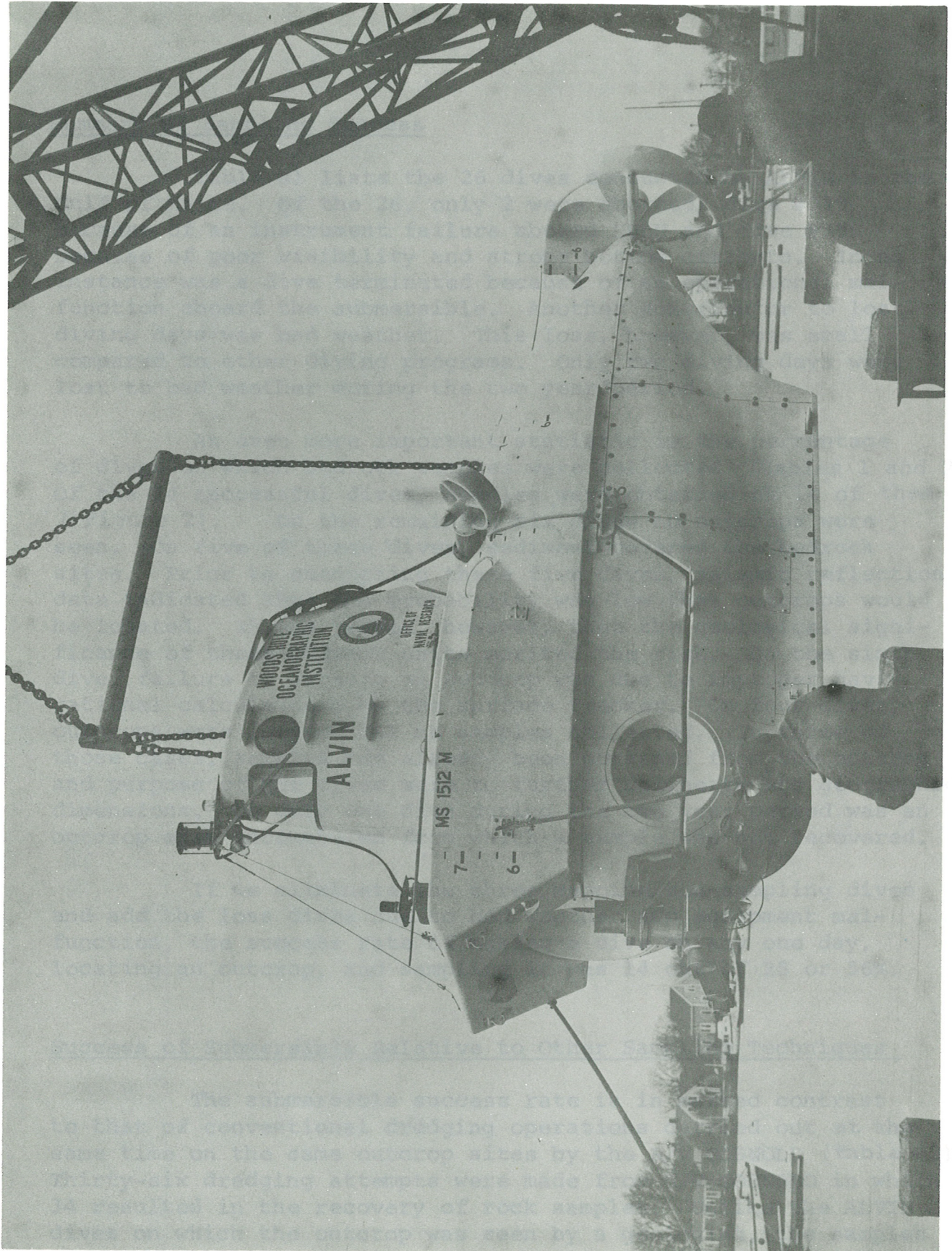


Figure 1. Woods Hole Oceanographic Institution's Research Submersible ALVIN.

Summary of Sampling Success

Table #1 lists the 26 dives conducted by ALVIN in the Gulf of Maine. Of the 26, only 2 were aborted; dive #339 because of an instrument failure aboard LULU and dive #350 because of poor visibility and strong bottom currents. In no instance was a dive terminated because of an operational malfunction aboard the submersible. Another contributor to lost diving days was bad weather. This loss, however, was small compared to other diving programs. Only two diving days were lost to bad weather during the two year period.

An even more important statistic is the percentage of dives on which bedrock samples were collected (tables 1 and 2). Of the 24 successful dives, samples were obtained on 14 of them (Figure 2). On the remaining six dives no outcrops were seen. On five of those dives, sediment covered the bedrock sites. Prior to conducting these five dives, seismic reflection data indicated that the probability was low that outcrops would be located. It was judged, however, that the geological significance of these bedrock units merited the risk. On the sixth dive, failure to acquire an outcrop was due to improper navigational calculations by the surface tracker. On four dives, outcrops were located but no samples collected. In three of those cases, samples had already been obtained from the outcrop and purpose of the dives were to further delineate its geographic dimensions. On only one dive during the two year period was an outcrop area encountered from which a sample was not recovered.

If we eliminate the three mapping/non-sampling dives and add the loss dives due to bad weather and equipment malfunction, the success rate of making a dive on any one day, locating an outcrop, and sampling it was 14 out of 25 or 56%.

Success of Submersible Relative to Other Sampling Techniques

The submersible success rate is in marked contrast to that of conventional dredging operations carried out at the same time on the same outcrop sites by the R/V GOSNOLD (table #2). Thirty-six dredging attempts were made from R/V GOSNOLD in which 34 resulted in the recovery of rock samples. Unlike the ALVIN dives on which the outcrop was seen by a geologist, the samples

TABLE 1

ALVIN DIVES IN GULF OF MAINE

LULU CRUISE NO.	ALVIN DIVE NO.	DATE	LOCATION	LAT. (N)	LONG. (W)	DEPTH	REMARKS
43	337	7/16/71	Murray Basin	42°25'	69°45'	242 m	Holocene Sediments
43	338	7/18/71	Cashes Ledge	42°51'	68°52'	108 m	Bedrock Samples
43	339	7/19/71	Sigsbee Ridge	43°01'	69°06'	82 m	Aborted
43	340	7/20/71	Sigsbee Ridge	43°01'	69°06'	74 m	Bedrock Samples
43	341	7/21/71	Jeffrey's Bank	43°26.5'	68°37'	128 m	Coastal Plain Sediments
43	342	7/22/71	Harvey Black Knoll	43°04'	69°15'	139 m	Bedrock Samples
47	348	9/4/71	Parker Ridge	42°43.5'	68°50.6'	111 m	Bedrock Samples
47	349	9/5/71	Parker Ridge	42°39.3'	68°50.5'	115 m	Bedrock Samples
47	350	9/7/71	Wildcat Knoll	42°23'	70°00'	210 m	Aborted
54	417	7/7/72	Wilkinson Divide	42°31.5'	69°38.1'	232 m	Glacial Till
54	419	7/9/72	Three Dory Ridge Southern Peak	43°09'	69°22.5'	130 m	Bedrock Samples

Table 1 (continued)

LULU CRUISE NO.	ALVIN DIVE NO.	DATE	LOCATION	LAT. (N)	LONG. (W)	DEPTH	REMARKS
54	421	7/11/72	Three Dory Ridge Central Peak	43°11.0'	69°21.0'	159 m	Bedrock Samples
54	423	7/13/72	Three Dory Ridge Northern Peak	43°13'	69°20'	136 m	Bedrock Samples
55	425	7/20/72	Mayo Swell	42°27'	69°16'	264 m	Glacial Till
55	426	7/21/72	Peck Ridge	42°50'	69°12'	124 m	Glacial Till
55	427	7/22/72	Fundy Fault Trend	43°23.0'	69°10.0'	95 m	Bedrock Samples
55	428	7/23/72	Fundy Fault Trend	43°42.5'	68°48'	97 m	Bedrock Seen
55	429	7/24/72	East of Cashes Ledge	43°02'	68°54'	124 m	Bedrock Samples
55	430	7/25/72	Cashes Ledge Northern Area	43°01'	68°59'	119 m	Bedrock Samples
55	431	7/26/72	Cashes Ledge Southern Area	42°46'	68°54'	88 m	Bedrock Samples
55	432	7/27/72	Rodgers Swell	42°29'	68°40'	194 m	Glacial Till
57	442	8/24/72	Cashes Ledge Central Area	42°50'	68°55'	115 m	Bedrock Seen

Table 1 (continued)

LULU CRUISE NO.	ALVIN DIVE NO.	DATE	LOCATION	LAT. (N)	LONG. (W)	DEPTH	REMARKS
57	443	8/25/72	Cashes Ledge Central Area	42° 50'	68° 55'	126 m	Bedrock Seen
57	444	8/26/72	Cashes Ledge Central Area	42° 50'	68° 55'	119 m	Bedrock Seen
57	445	8/27/72	Cashes Ledge Central Area	42° 50'	68° 55'	122 m	Bedrock Samples
57	447	8/29/72	Cashes Ledge Central Area	42° 50'	68° 55'	137 m	Bedrock Samples

TABLE 2

COMPARISON OF SAMPLING TECHNIQUES

<u>Technique</u>	<u>Attempts</u>	<u>Successful</u>	<u>Percentage</u>
SUBMERSIBLE	25 potential diving days	14 dives on which samples were collected	56%
Mechanical arm with pry bars	13	12	92%
Small diamond drill	3	2	66%
Impact hammer	3	0	0%
CONVENTIONAL DREDGING OPERATIONS	36	0	0%
SURFACE LOWERED DIAMOND BIT DRILL	8	1	12%
SCUBA DIVERS TO SHALLOW DEPTHS	3	1	33%

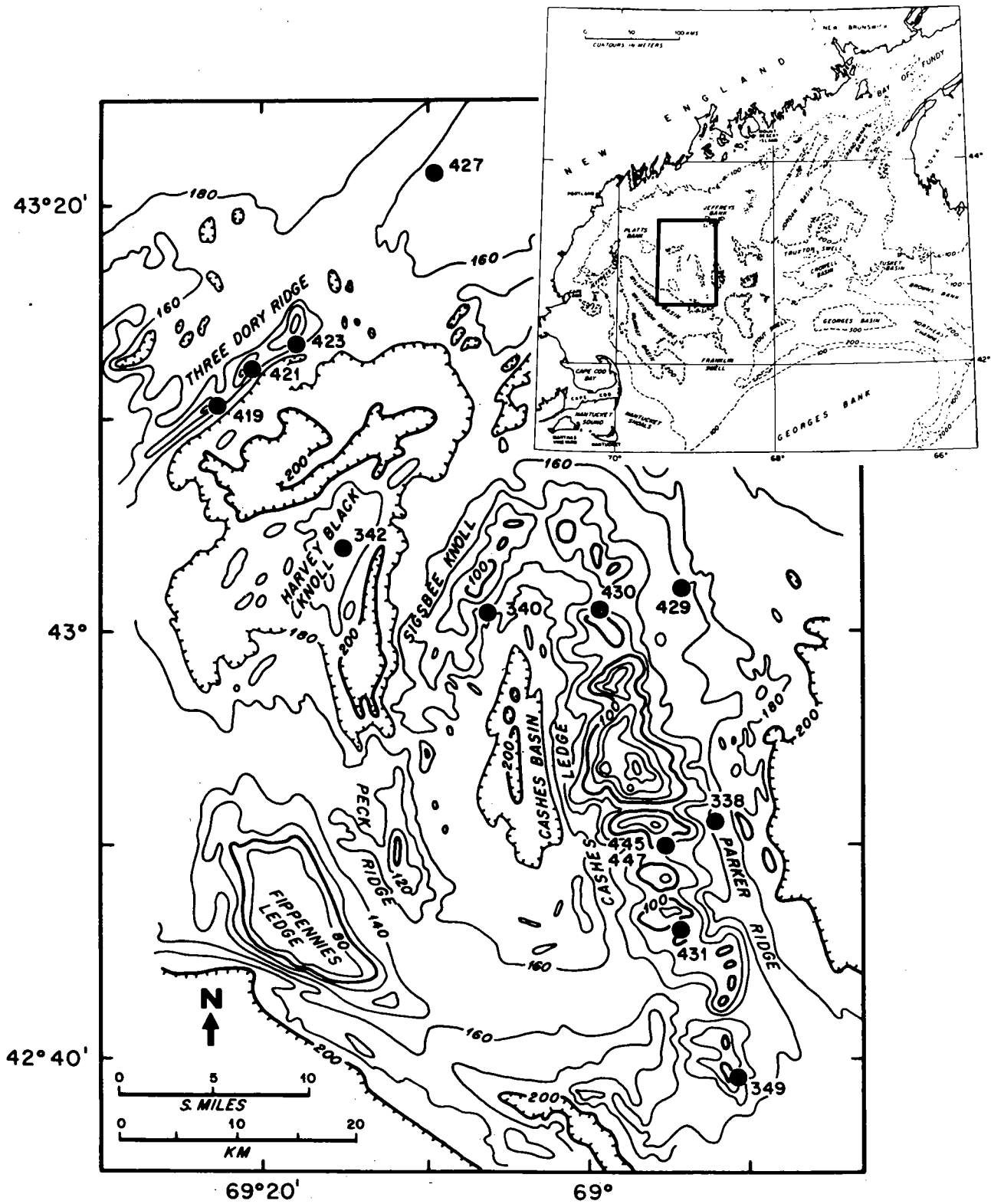


Figure 2. Dive Locations At Which Samples Of Bedrock Were Collected.

collected at any one site had the same composition and were broken off a larger rock.; all of the dredge hauls contained more than one rock type (in most cases in excess of five rock types) and the rounded nature of the samples suggest glacial transport. In addition, when samples collected by the submersible were compared with dredge samples speculated to represent the same outcrop, they differ 100% of the time. These observations led to the conclusion that dredging operations from surface ships in the Gulf of Maine are next to useless due to glacial contamination and that their only value is on a statistical probability basis.

Two other sampling techniques were used to obtain samples in the Gulf of Maine (table 2). These were the deployment of a large diamond bit drill from a surface ship (Williams and Davis, in preparation; figure 3) and the use of SCUBA divers (figure 4). In the first instance, the drill was lowered on eight occasions and successfully recovered one core. On the other seven attempts, the drill operated properly but evidently landed on a sediment covered bottom. Three dives using SCUBA divers resulted in the recovery of one sample. The first dive was made to 30 meters on Fishing Ledge in the center of Cape Cod Bay. Only ice rafted boulders were seen. The second dive was to 47 meters on an outcrop south of Jeffrey's Ledge (42°46'N, 70°13'W) which had been inspected and photographed by divers the summer before (1972). This dive was unsuccessful since the divers were making a bounce dive on normal compressed air and had insufficient time to break-off a sample. The ship re-anchored in shallower water (i.e. 42 meters) and a second attempt at that site resulted in the collection of one sample weighing approximately 3.2 kg. It took 15 minutes to break off this sample from a large outcrop using a pry bar.

Sample Inventory and Relative Sampling Success of Each Submersible Dive

The amount of bedrock samples recovered by the submersible ALVIN varied greatly from one dive to the next. Table 3 lists the number of samples collected, their individual weights, and the total weight for each dive. The largest single sample weighed 17.7 kg and the greatest total weight was 64.5 kg. Figure 5 shows the total weight collected plotted against time; both as a combined sum and by individual pilots. It is clear from the figure that the total amount collected on any one dive increased with time. This was due to a combination of experience and technique. Dive #338, for example, was the first attempt made by ALVIN to collect



Figure 3. Rock Drill Being Lowered By GOSNOLD.

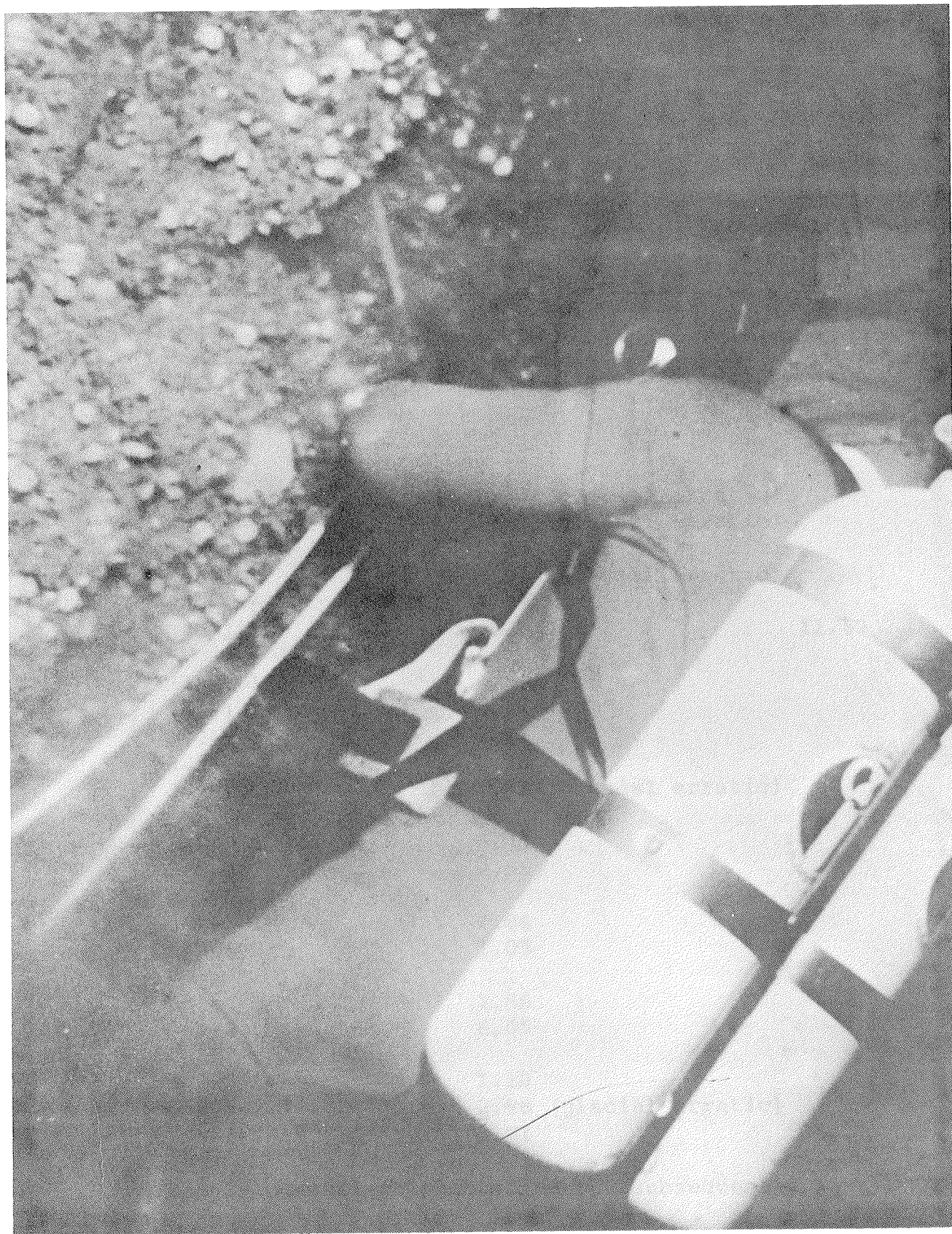


Figure 4. Scuba Diver Recovering Sample From Outcrop South of Jeffrey's Ledge.

TABLE 3

SAMPLES TAKEN BY ALVIN IN GULF OF MAINE

<u>DIVE NUMBER</u>	<u>SITE NUMBER</u>	<u>SAMPLE WEIGHT (Kg)</u>	<u>TOTAL WEIGHT (DOES NOT INCLUDE GLACIAL ERRATICS) (Kg)</u>
338	338-1-1	.19	
	338-2-1 (never re- covered)		
	338-3-1	.08	.27
340	340-1-1	4.32	
	340-1-2	2.73 (glacial erratic)	
	340-1-3	.91 (glacial erratic)	
	340-1-4	1.05 (glacial erratic)	
	340-1-5	5.91 (glacial erratic)	
	340-1-6	6.59	
	340-1-7	.68	11.59
342	342-1-1	6.55	
	342-1-2	1.14	
	342-1-3	1.41	
	342-1-4	2.38	
	342-1-5	.32 (glacial erratic)	
	342-2-1	5.73	
	342-2-2	2.55	
	342-3-1	1.86	
	342-3-2	1.05	
	342-4-1	2.86	
	342-4-2	6.05	
	342-5-1	1.18	
	342-5-2	2.96 (glacial erratic)	
	342-5-3	3.91	36.59
348	348-1-1 (small chip obtained but subsequently lost)		

Table 3 (Continued)

<u>DIVE NUMBER</u>	<u>SITE NUMBER</u>	<u>SAMPLE WEIGHT (Kg)</u>	<u>TOTAL WEIGHT (DOES NOT INCLUDE GLACIAL ERRATICS) (Kg)</u>
349	349-1-1	2.50	5.55
	349-1-2	3.05	
419	419-1-1	7.86	16.73
	419-1-2	6.14	
	419-1-3	2.73	
421	421-1-1	.50	2.55
	421-1-2	.46	
	421-1-3	1.59	
423	423-1-1	1.14	1.14
	423-2-1	5.73 (suspected glacial erratic)	
427	427-1-1	4.77	4.77
429	429-1-1	17.86	45.55
	429-1-2	12.32	
	429-1-3	11.05	
	429-2-1	4.32	
430	430-1-1	2.46	4.32
	430-2-1	1.32	
	430-2-2	.55	
431	431-1-1	10.36	48.73
	431-2-1	5.23	
	431-2-2	16.59	
	431-2-3	7.23	
	431-2-4	9.32	

Table 3 (continued)

<u>DIVE NUMBER</u>	<u>SITE NUMBER</u>	<u>SAMPLE WEIGHT (Kg)</u>	<u>TOTAL WEIGHT (DOES NOT INCLUDE GLACIAL ERRATICS) (Kg)</u>
445	445-1-1	13.86	
	445-1-2	4.41	
	445-1-3	3.36	
	445-1-4	5.64	
	445-1-5	3.14	
	445-1-6	2.91	
	445-1-7	2.77	
	445-1-8	1.68	
	445-1-9	2.05	
	445-2-1	9.73	
	445-2-2	4.14	
	445-2-3	4.18	
	445-2-4	1.36	
	445-2-5	.50	
	445-2-6	.96	
	445-2-7	1.55	
	445-2-8	1.23	
	445-2-9	1.27	64.73
447	447-1-1	10.82	18.82

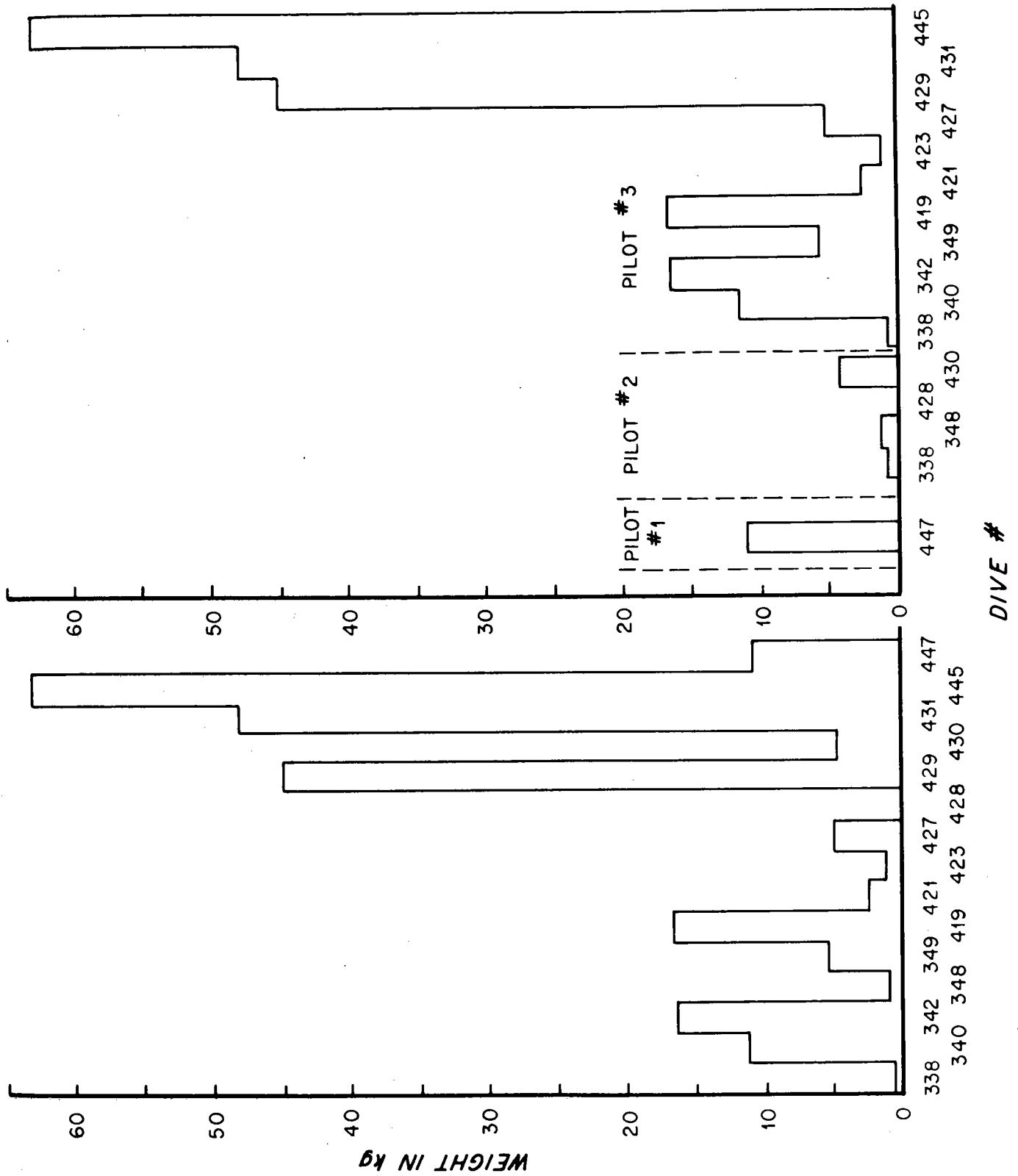


Figure 5. Total weight of samples collected during each dive as a function of time and as a function of individual pilot.

crystalline rock. With time, the pilots who operate the submersible's mechanical arm and recover the samples became more experienced in maneuvering the submersible over the outcrop in water visibility which averaged 4.5 meters and bottom current which averaged 13 cm/sec. The pilots also developed a better understanding of what the scientists wanted and picked up less glacial erratics as time went on (table 3).

The poor recovery weights on dives 338 and 349 are related also to sampling technique. In the early dives of 1971 attempts were made to collect samples using a small diamond-bit drill held by the mechanical arm (table 3). This technique proved unsatisfactory and was abandoned. On dives 419, 421, and 423 a proto-type hydraulic impact hammer was used on several occasions but failed to break-off any samples due to insufficient impacting energies. The use of this technique also resulted in lowering the recovery rate. The most successful sampling technique used to date from ALVIN has been the use of steel pry bars by the mechanical arm. Once the outcrops were located, using the submersible's CTFM sonar, the pilot would fly over the bedrock surface at an altitude of approximately 93 cm. The pilot would crab the submersible to the port side to provide the senior scientist with the best possible view of the bottom. Since all the outcrops, but one, proved to be granitic in composition, they commonly contained major joints. Once one of these joints was encountered, the pilot would drive along its strike while the scientist looked for rock specimens which were fractured in place and were small enough for the mechanical arm to pick up. In the early dives the pilot and scientist would stop at numerous sites where an hour, or in some cases four hours, would be spent unsuccessfully attempting to pry samples loose. In the later and more successful dives, greater care and time was given to selecting the sample sites. As a result, less attempts were made but the overall weights recovered increased dramatically (table 3). Figure 5 also shows that the amount recovered during a dive depended greatly on the pilot, even though they had similar diving experience.

Dive Summaries

The following are short summaries of the 26 dives listed in Table 1. Only a few representative photographs are shown for each dive. Their primary purpose is to help document the validity

of the samples collected. Several thousand additional photographs were taken during the dives and are stored in the Institution's data archives.

In these summaries, minor mention is given to the scientific results associated with this work. These scientific observations and the petrologic and radiometric significance of the samples collected are contained in Ballard (in preparation).

DIVE #338

Location = Cashes Ledge
42°51'N, 68°52'W

Date Conducted = 18 July 1971

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: This was the first hardrock dive made by ALVIN in the Gulf of Maine. The primary mission of the dive was to locate an outcrop of crystalline rock and sample it using a small diamond bit coring device. The dive lasted between seven and eight hours. The bottom ranged in depth from 107 to 142 m having variable relief but consisting primarily of a smooth low level outcrop surface. During the course of the dive, numerous attempts were made to collect rock samples using a small drill. These efforts on the whole were unsuccessful as the submersible proved to be highly unstable during drilling operations leading to frequent motions of the vehicle and subsequent jamming of the drill. As a result only two small core samples were recovered. Figure 6 is a picture taken during the collection of one such sample showing the method of drilling and the general nature of the outcrop surface. The magnetic compass on the tray shows that the submersible is headed north. The drill was spring-loaded against the outcrop using the ALVIN's mechanical arm. Once in position the electric-driven rotating diamond bit was turned on by the pilot who then maintained a load on the drill using the arm. Penetration was monitored visually through the forward port hole. At a depth of approximately four inches, the drill was moved in a jerking motion to break off the sample. The drill pump motor was then reversed to hold the sample in the bit and the drill removed from the hole. Figure 6 shows a series of numbered plastic tubes mounted on the tray. The drill was inserted in one of these tubes, the pump motor reversed, and the sample ejected into the tube.



Figure 6. Mechanical Arm Holding Diamond Bit Drill
During Sampling Operations on Cashes Ledge.

Description of Samples: Two small cores were collected; the first, weighing 19.5 grams, was collected at a depth of 107 m and the second, weighing 8 grams, was taken at the same site. Despite their small size a thin section was made of the first sample. The outcrop was found to have a granitic composition. A complete description of the thin section is contained in Ballard (in preparation).

DIVE #339

Location = Sigsbee Ridge
43°02'N, 69°06'W

Date Conducted = 19 July 1971

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = L. King

Short Dive Description: Aborted due to failure of
support ship's gyro.

Dive #340

Location = Sigsbee Ridge
43°02'N, 69°06'W

Date Conducted = 20 July 1971

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = L. King

Short Dive Description: The submersible landed on a sand and gravel bottom at a depth of 74 m. ALVIN then drove in a westerly direction and within 10 minutes encountered a rock outcrop. Figure 7 shows the general nature of the exposure with a near vertical east wall and a gently sloping (10°) west flank. The submersible proceeded to the top of the outcrop, landed, and attempted to use the diamond bit core (70 m). One hour was spent attempting to use the core but ended unsuccessfully after the drill handle broke off. A general inspection of the outcrop was made during which vertical joint patterns were observed and numerous photographs taken. Figures 8 and 9 are photos of the outcrop which show vertical rock cleaving resulting in the fracturing of some of the outcrop into smaller blocks. During this traverse the submersible landed twice to collect apparent fractured pieces.

Description of Samples: A total of seven samples were collected; two at the first site and five at the second site. Subsequent inspection of those samples indicated that the second, third, fourth, and fifth samples were glacial erratics. This determination was based upon (1) that all were near outcrops but the samples themselves were lying by themselves on a sediment bottom, (2) all were highly rounded suggesting glacial transport, (3) none exhibited fresh fractural surfaces, and (4) all had different rock compositions, none of which agreed with the more documented samples. The remaining three samples (one at the first site and two at the second, had similar compositions and fresher, non-rounded surfaces. The total weight of the three samples was 25.5 lbs (11.6 kg). A thin section of Alv 340-1-7-A was made. The rock is granitic in composition. A complete description is found in Ballard (in preparation).

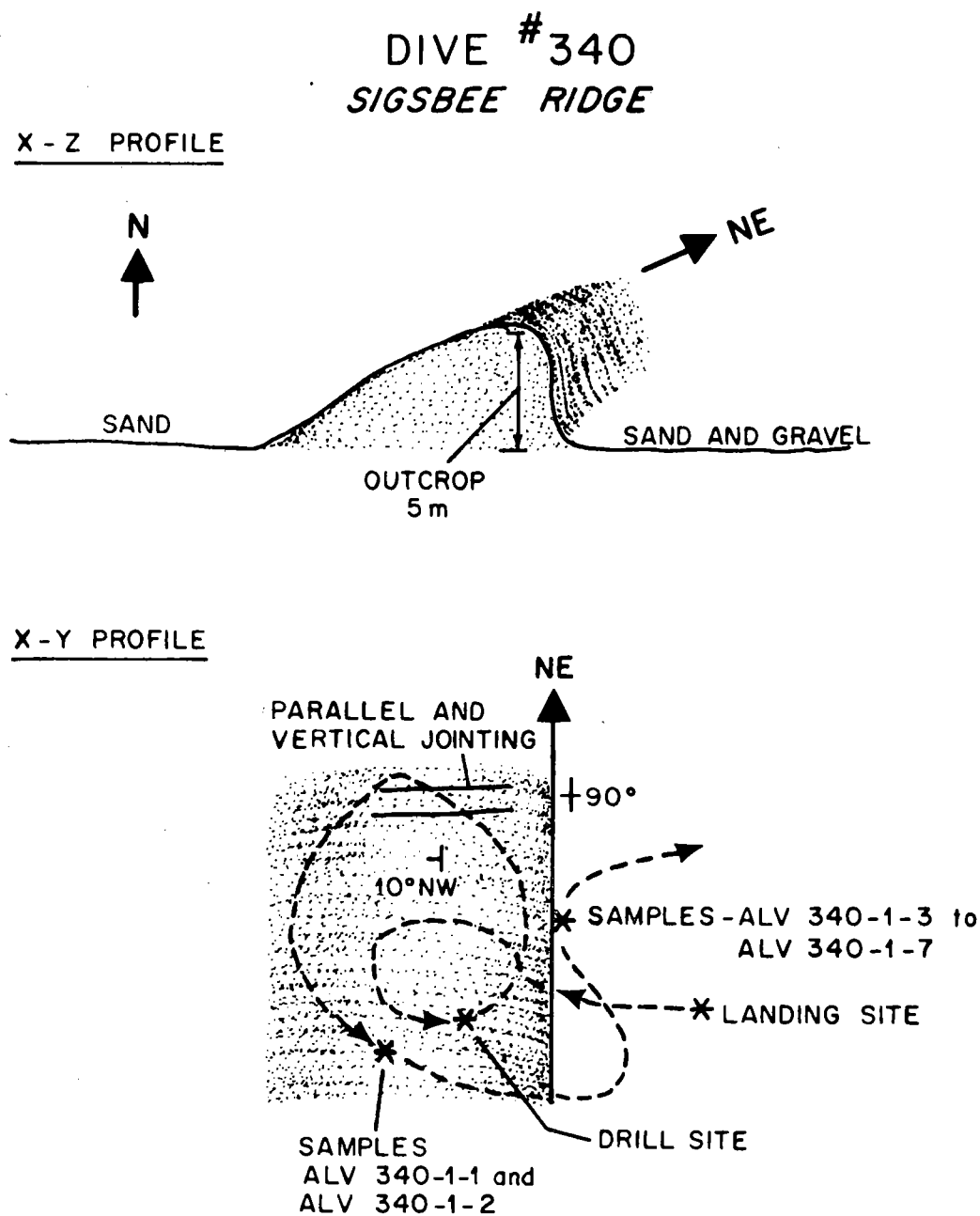


Figure 7. Profiles showing general nature of outcrop on Sigsbee Ridge. Dashed line in x-y profiles. Shows track of submersible over bottom.

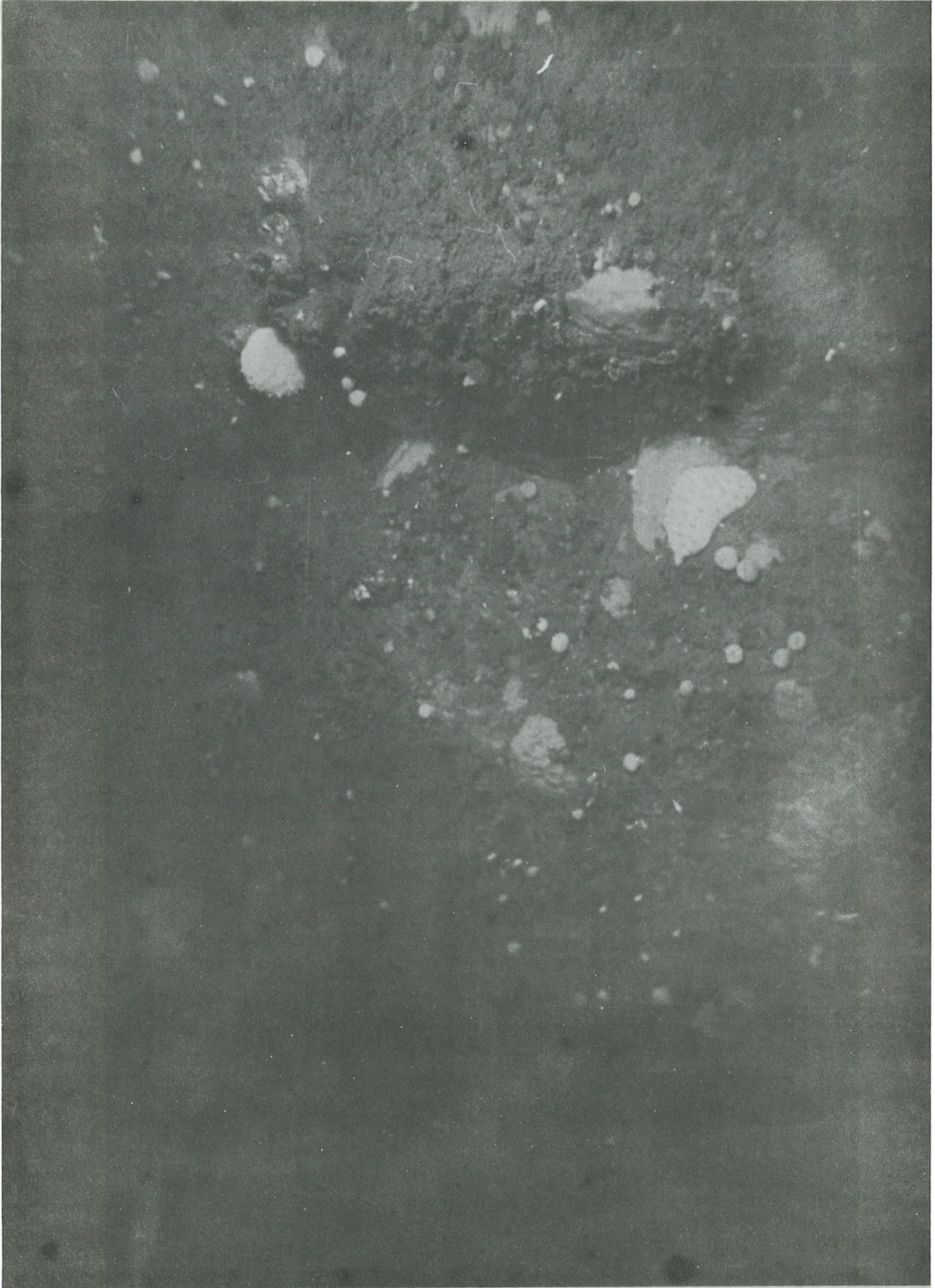


Figure 8. Rock Cleavage Along Which Slight Dip Slippage Has Occurred.

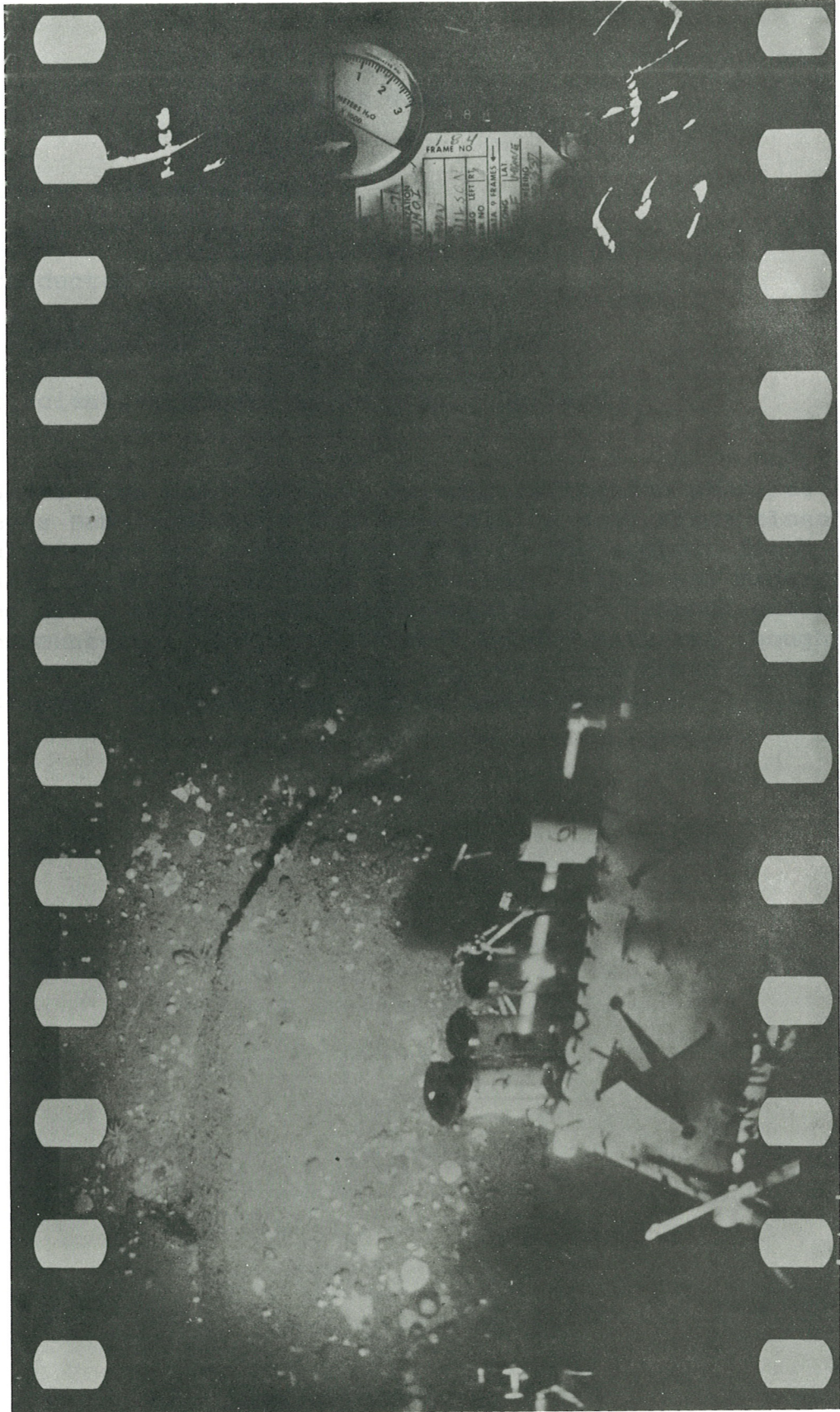


Figure 9. Rock Cleavage And Associated Rock Fragments.

Dive #341

Location = Jeffrey's Bank
43°26.5'N, 69°37'W

Date Conducted = 21 July 1971

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: Seismic reflection profiles across Jeffrey's Bank indicated that crystalline rock rises close to the surface and may actually outcrop on the eastern flank of the bank. With that in mind a nine-hour search was made of the sea floor using ALVIN. Unfortunately no bedrock outcrops were encountered. Outcrops of soft bedded material thought to be part of the Coastal Plain sequence were found at 117 m but attempts to sample them proved unsuccessful.

Dive #342

Location = Harvey Black Knoll
43°04'N, 69°15'W

Date Conducted = 22 July 1971

Chief Scientist of Cruise = R.D. Ballard

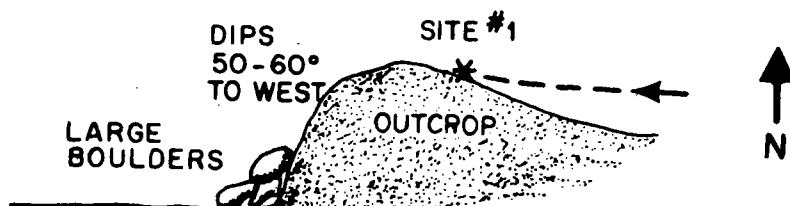
Senior Scientist Aboard ALVIN = L. King

Short Dive Description: The submersible landed on a sediment bottom at a depth of 131 m. ALVIN apparently drove south and encountered a block ridge line at a depth of 125 m. Figure 10 shows the generalized track of ALVIN while Figures 11 and 12 are photos taken at Site #1. The submersible proceeded southwest along the ridge line collecting samples at five separate sites. The outcrop had a strike of 210°, was highly fractured in many areas, and generally of low relief, rising 16 meters over a distance of approximately 300 meters.

Description of Samples: 14 samples were collected at five separate locations. Two of the samples later proved to be glacial erratics for the previously stated reasons. The remaining 12 samples were of a rhyolitic composition and had a combined weight of 80.5 lbs. (36.5 kg). Their detailed composition is contained in Ballard (in preparation).

DIVE #342
HARVEY BLACK KNOLL

X-Z PROFILE



X-Y PROFILE

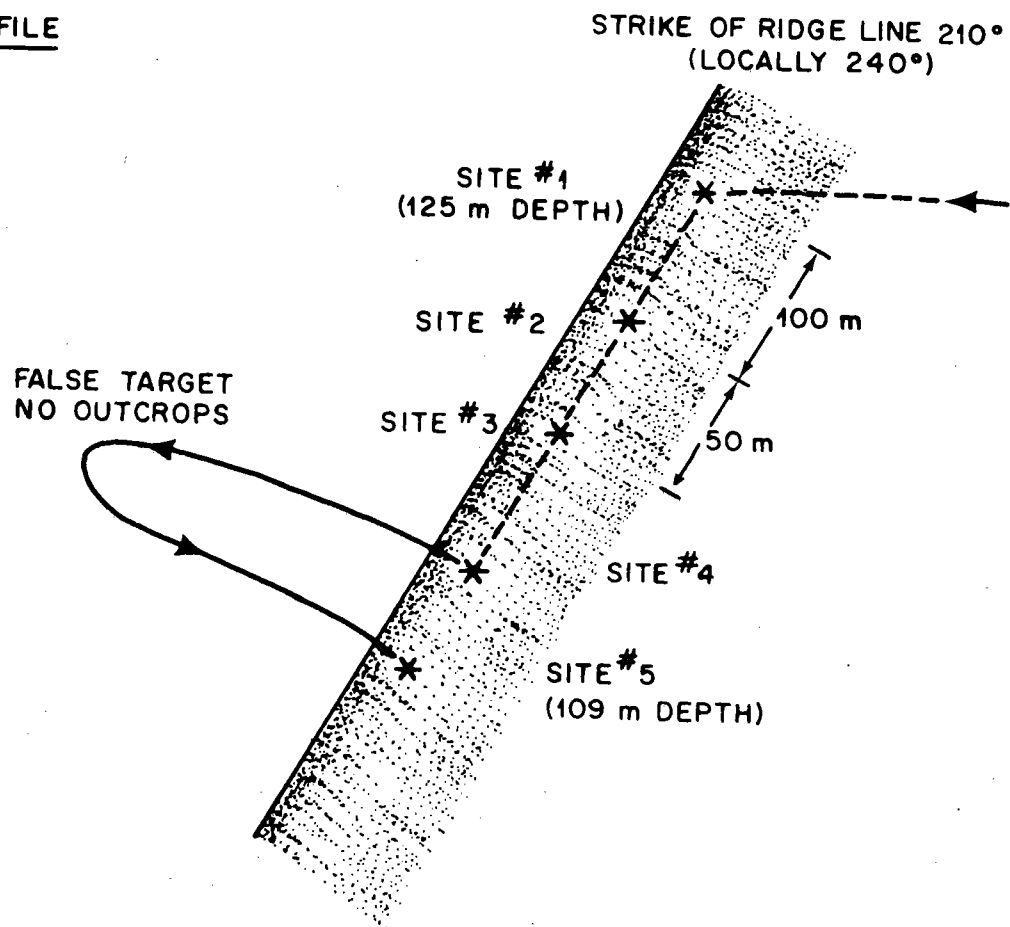


Figure 10. Profiles showing general nature of outcrop surface on Harvey Black Knoll. Dashed line shows track of submersible over bottom.

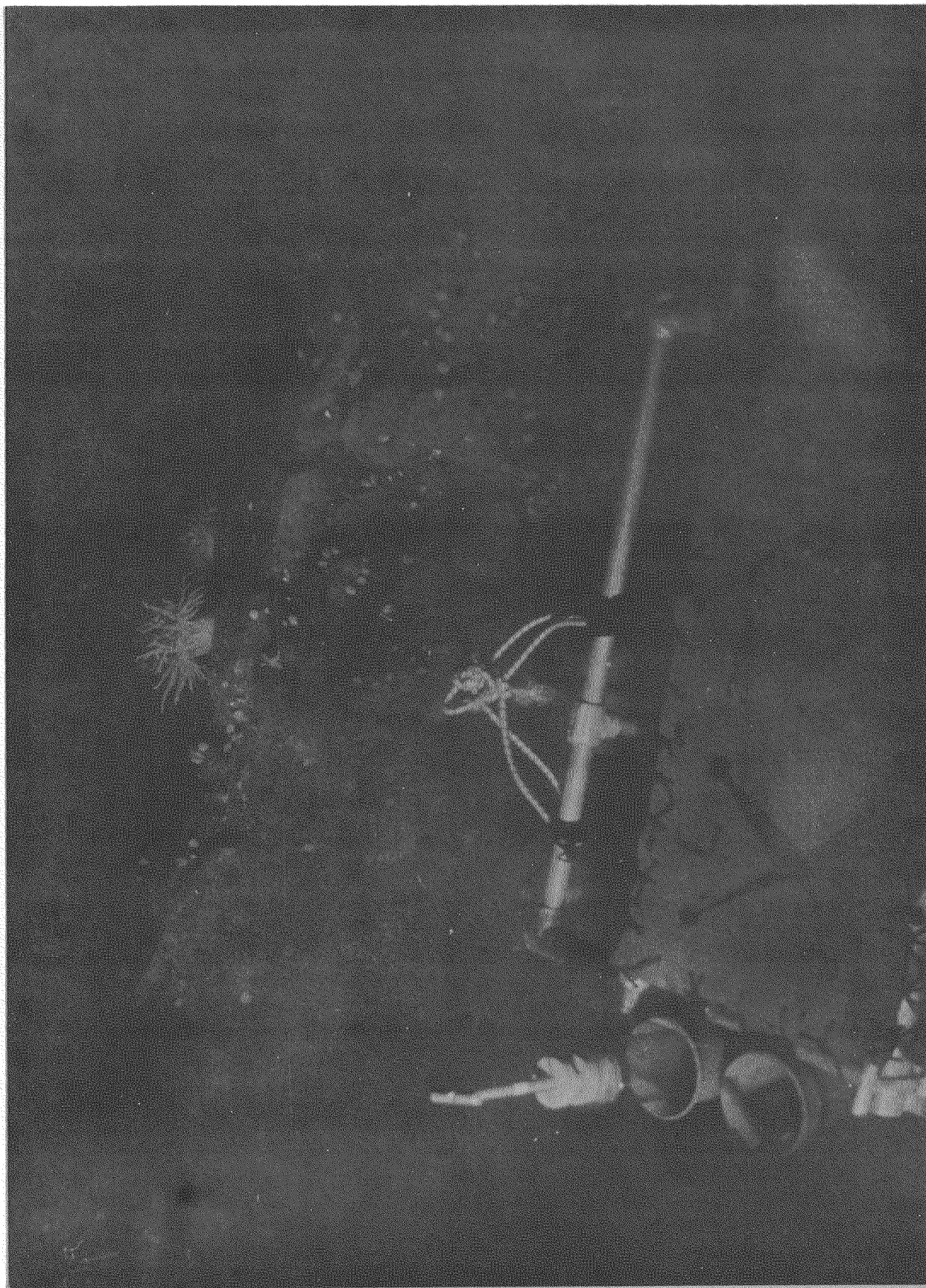


Figure 11. Submersible Positioned Perpendicular to Strike of Fractured Ridge Line.



Figure 12. Mechanical Arm Picking Up Sample at Site #1.

Dive #348

Location = Parker Ridge
42°43.5'N, 68°50.6'W

Date Conducted = 4 September 1971

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: The submersible landed on a sediment bottom at a depth of 98 m. Within five minutes a possible outcrop target was located on the CTFM sonar at a range of 200 m and bearing of 090°. The ALVIN travelled in that direction and encountered an outcrop approximately 1 hour and 25 minutes later at a depth of 111 m. (Figure 13). A small core sample was obtained at this site (Figure 14). The submersible then moved 50 yds. away to a jointed section of outcrop at which it spent the remainder of the dive unsuccessfully attempting to pry rock samples loose using the mechanical arm. Figure 15 is a photo taken during the later part of the dive of a small terraced surface or bench in the outcrop with a relief of 1-2 meters. According to a magnetic compass on the tray, the strike of the feature is N-S with a vertical face dipping east.

Description of Sample: A very small rock chip was collected at site #1. Subsequent inspection of the chip and comparison with samples taken on Dive #349 to the south showed the outcrop to be of granitic composition and identical to Dive #349 samples which are described in detail in Ballard (in preparation).

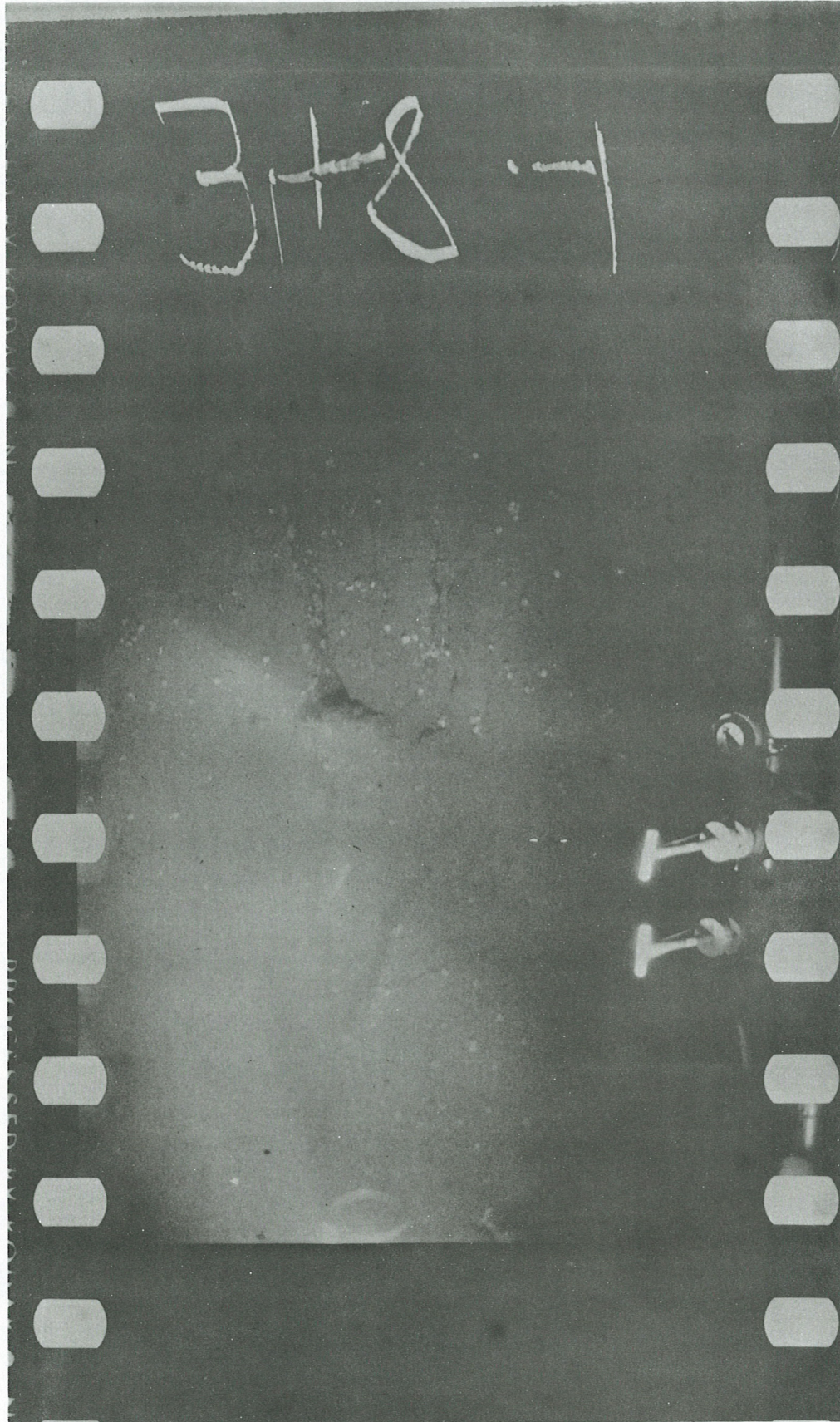


Figure 13. Joint in Granite Outcrop Running Northeast-Southwest Which Was Encountered During First Part of Dive on Parker Ridge.



Figure 14. Using Diamond Bit Drill to Obtain Small Sample on Parker Ridge.

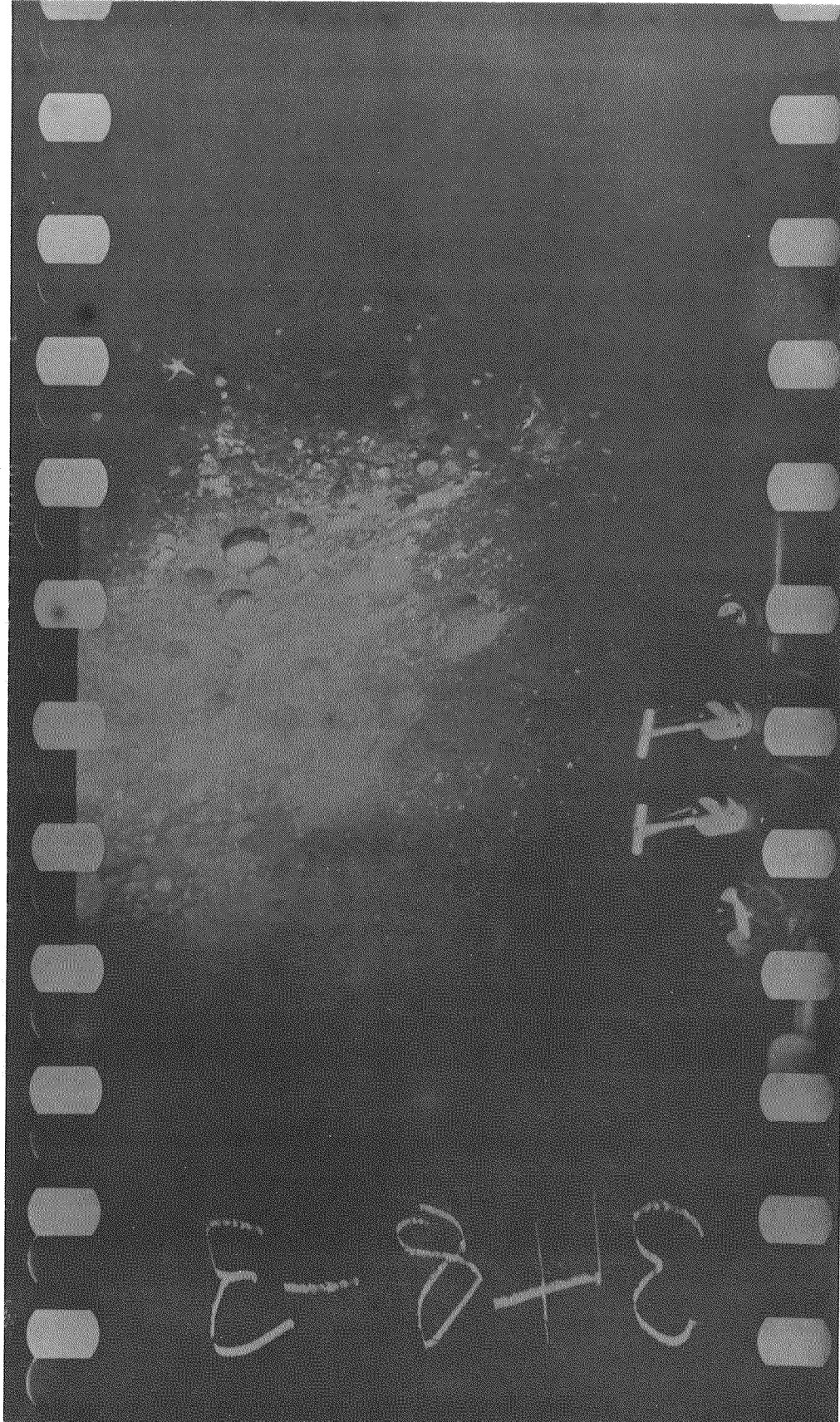


Figure 15. Small Vertical Step in Outcrop Surface.

Dive #349

Location = Parker Ridge
42°39.3'N, 68°50.5'W

Date Conducted = 5 September 1971

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard.

Short Dive Description: The submersible landed on a sediment covered bottom at a depth of 70 m. It then drove in a northwesterly direction encountering an outcrop within 20 minutes at a depth of 75 m. Following a brief inspection of the outcrop the submersible successfully recovered a rock sample by prying a keystone fragment of a vertical joint (Figure 16). The submersible then moved a short distance to another portion of the outcrop (Figure 17) where a second sample was obtained. Following this sampling effort the submersible left the bottom and proceeded east for over 30 minutes in hopes of locating a second outcrop. No subsequent outcrops were encountered and the dive ended.

Description of Samples: Two samples were collected during the dive, both of which are shown in Figures 16 and 17. In Figure 16 the sample is lying on its side having just been pried out of a joint. The sample is highly weathered and weighs 2.5 kgs. The second sample was pried out of a large block and is shown within the square on Figure 17. A thin section was made of the latter rock and found to be granitic in composition (Ballard, in preparation). A sample of this rock was dated by K-Ar (15% biotite, 80% pyroxene, 5% other minerals) techniques and found to have a minimum age of 351 m.y. (Ballard, in preparation).



Figure 16. Arrow Shows Sample Which Mechanical Arm
Pried From Joint in Center of Photograph
(Sample ALV-349-1-1).

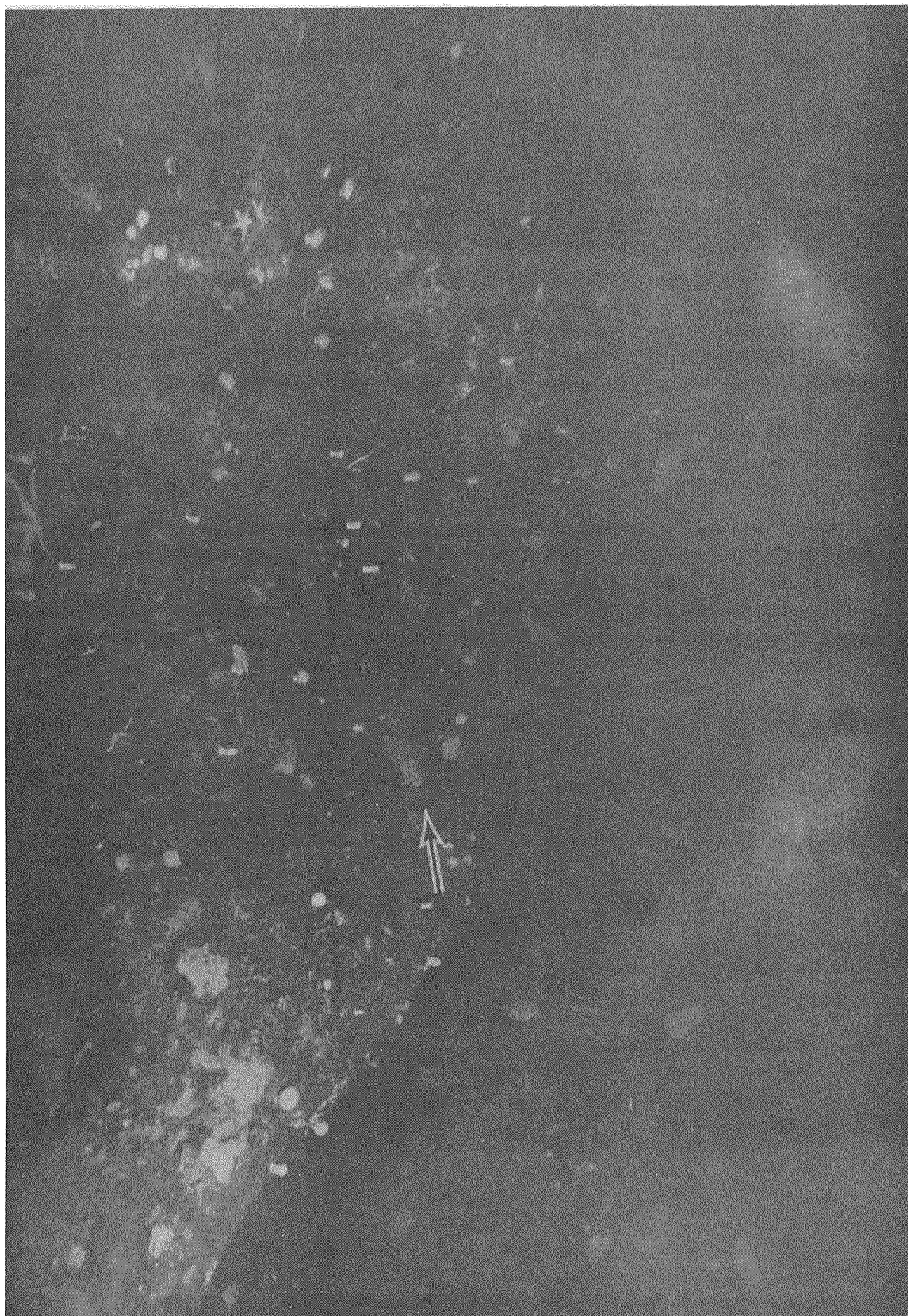


Figure 17. Arrow Shows Orientation of Sample Prior to Being Collected (Sample ALV-349-1-2).

Dive #350

Location = Wildcat Knoll
42°23'N, 70°00'W

Date Conducted = 7 September 1971

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R. Oldale

Short Dive Description: The submersible landed on a sediment bottom at a depth of 185 m. The current was so strong (in excess of 1 knot) and the visibility so poor (less than 1.5 m) that work on the bottom was terminated in less than 30 minutes and no useful observations were made.

Dive #417

Location = Wilkinson Divide
42°31'N, 69°37'W

Date Conducted = 7 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: Seismic reflection profiles and magnetic information indicated that Wilkinson Divide may contain exposed outcrop surfaces thought to be Triassic intrusives of basaltic composition. The purpose of the dive was to locate and sample any outcrop surfaces. Unfortunately no outcrops were located and subsequently no samples recovered.

Dive #419

Location = Three Dory Ridge (Southern Peak)
43°09.5'N, 69°22.5'W

Date Conducted = 9 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: The submersible landed on a sediment bottom at a depth of 145 m. ALVIN drove in a southeastern direction, and using its CTFM sonar, located an outcrop 20 minutes later. Several attempts were made to break off samples using a newly developed spring-loaded hydraulic impact hammer (Figure 18). Unfortunately operational difficulties and insufficient impacting energies negated breaking any samples loose. A fractured block was subsequently located on the outcrop at a depth of 130 m, from which three samples were recovered using the mechanical arm (Figure 19).

Description of Samples: Three samples weighing a total of 36.8 lbs (16.7 kg) were recovered at station #3. Figure 19 shows the fractured block from which these were taken. A thin section was made from Alv-419-1-1 and found to have a granitic composition (Ballard, in preparation).

Magnetics: A submersible towed magnetometer was used intermittently during the dive and recorded a field of 56565.7 gammas near station #3, site #1, where the samples were collected.



Figure 18. Hydraulic Impact Hammer Being Used Unsuccessfully in an Attempt to Break-off Outcrop Samples.

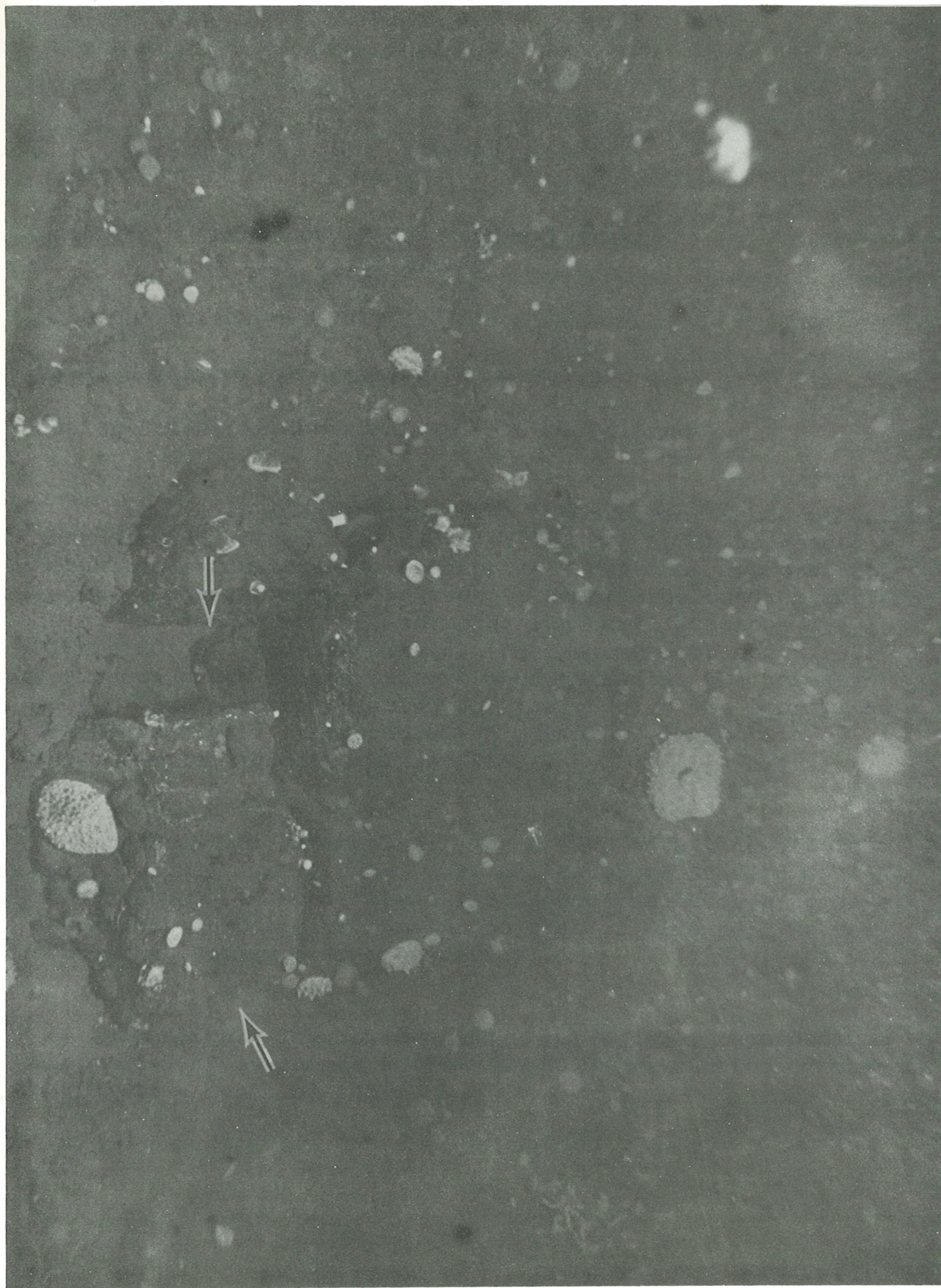


Figure 19. Arrows Show Locations of Two of the Samples Collected at This Site.

Dive #421

Location = Three Dory Ridge (Central Peak)
43°11.0'N, 69°21.0'W

Date Conducted = 11 July 1972

Chief Scientist of Cruise = R. D. Ballard

Senior Scientist Aboard ALVIN = R. D. Ballard

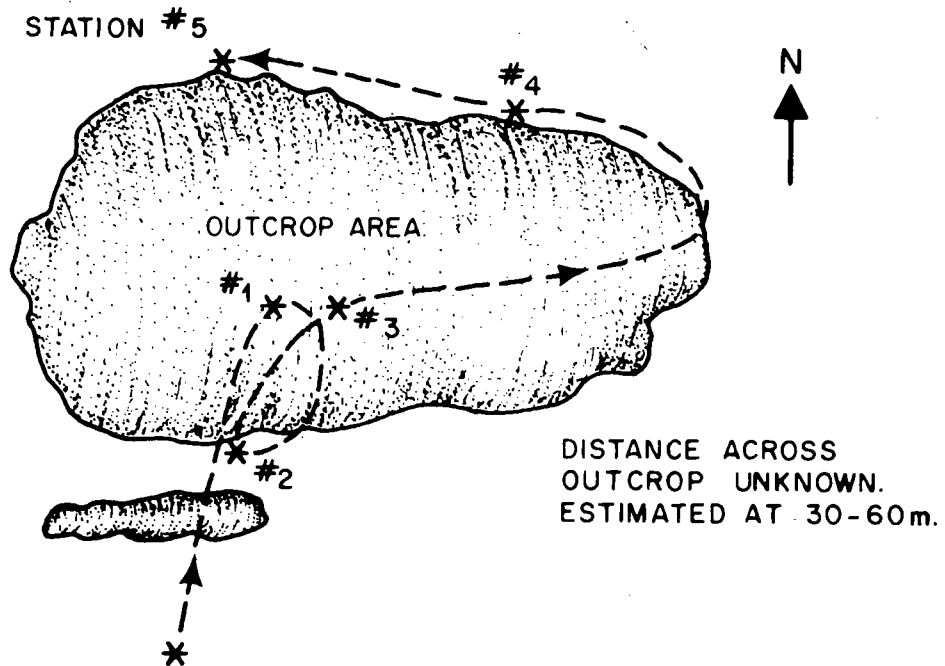
Short Dive Description: The submersible landed on a sediment covered bottom at a depth of 159 m. ALVIN proceeded north and encountered an outcrop at a depth of approximately 145 m. Four attempts were made to sample the outcrop surface using the impact hammer and mechanical arm (Stations 1-4, Figure 20) but none succeeded. Near the end of the dive a region of block fracturing was encountered at the northern edge of the outcrop (Station 5, Figure 20). The top of one block was highly fractured which permitted collection of three samples (Figures 21 and 22).

Description of Samples: Three samples having a total weight of 5.2 lbs (2.3 kg) were collected at Station #5. A thin section of sample Alv-421-2 showed the outcrop to have a granitic composition similar to that of Dive #419 to the southwest (Ballard, in preparation).

Magnetics: The towed proton magnetometer recorded a field of 56390.4 gammas at Station #5 while sitting on the bottom in a depth of 145 m.

DIVE #421

X-Y PROFILE



X-Z PROFILE

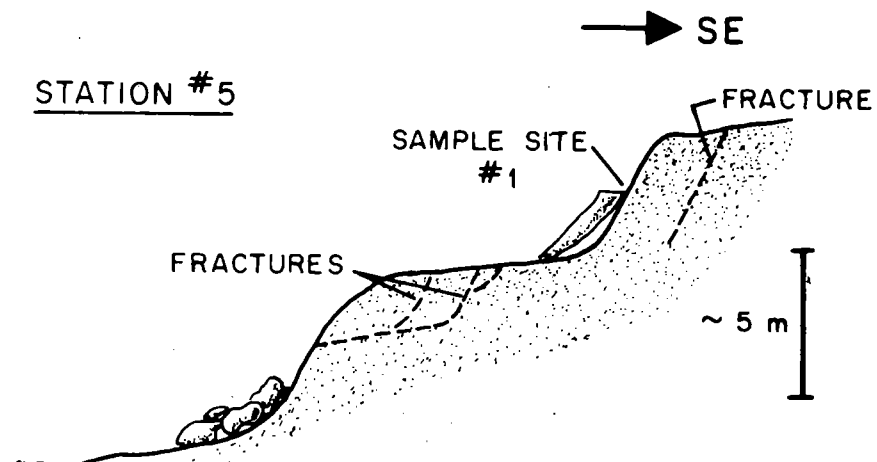


Figure 20. Profiles showing general nature of outcrop surface. Dashed line shows track of submersible over bottom.



Figure 21. Arrow Shows Location of Sample Taken From Top of Fractured Block.



Figure 22. Mechanical Arm Picking Up Sample.

Dive #423

Location = Three Dory Ridge (Northern peak)
43°13.0'N, 69°20.0'W

Date Conducted = 13 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: The submersible proceeded to the bottom and landed on a sediment surface covered with glacial erratics. ALVIN headed on a NW course, obtained a good target on its sonar, and subsequently encountered a steep scarp. The vessel spent the first half of the dive attempting, unsuccessfully, to sample the outcrop at a variety of locations. It was not until the very end of the dive that two samples were collected from the top of the formation.

Description of Samples: Figures 23 and 24 are photographs of sample Alv-423-1 and Alv 423-2 respectively taken prior to their recovery. A thin section of Alv-423-1 shows it to be of granitic composition similar to those obtained on the ridges to the south (Dives 419 and 421; Ballard, in preparation). The second sample appears to have been a glacial erratic.

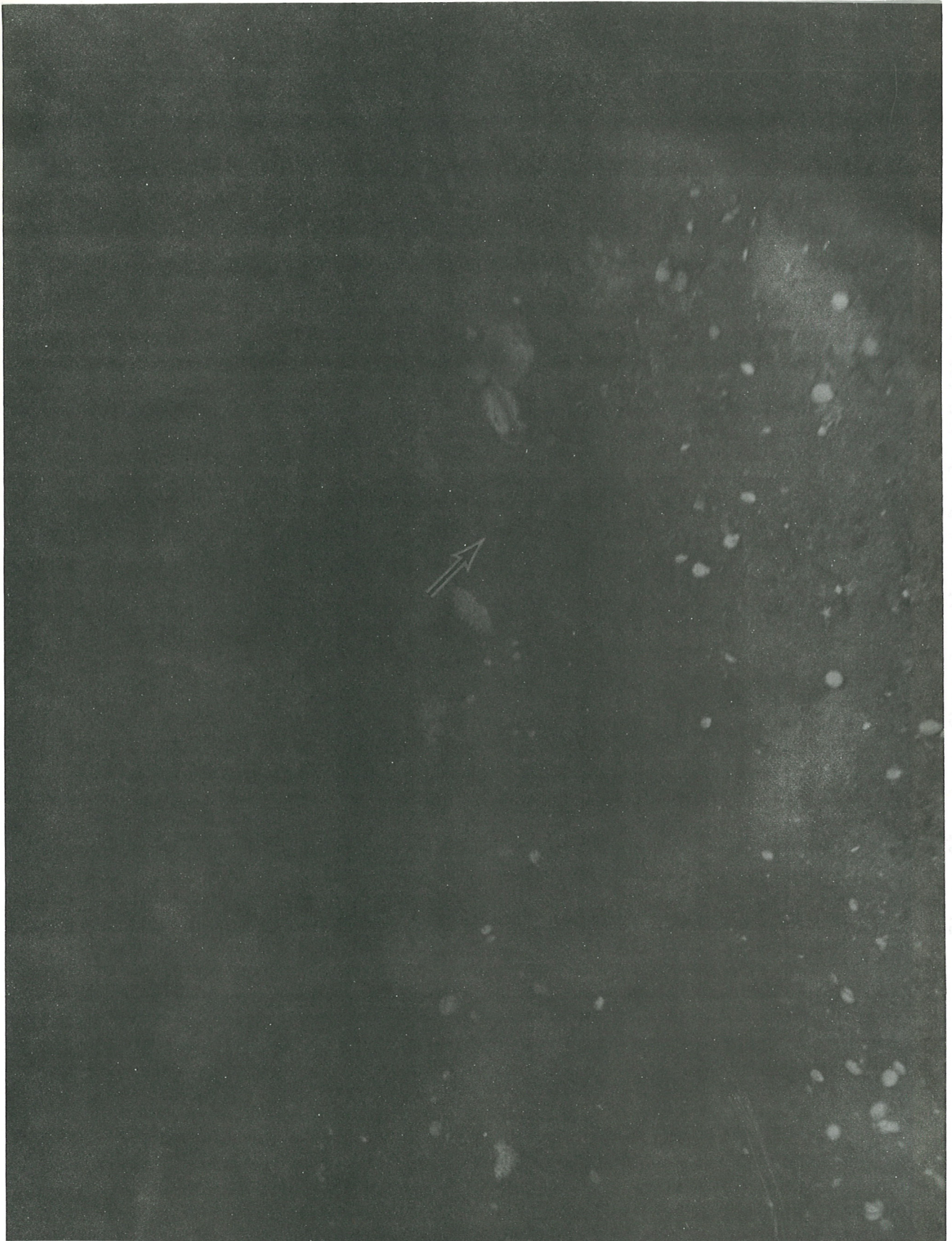


Figure 23. Arrow Shows Location of Sample ALV-423-1-1
Before Rock was Pried Loose.



Figure 24. Arrow Shows Location of Sample ALV-423-2-1 Prior to Collection. Subsequent Inspection Indicated Sample Had Ice Rafted Origin.

Dive #425

Location = Mayo Swell
42°27'N, 69°16'W

Date Conducted = 20 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = L. King

Short Dive Description: Due to the slow cruise speed of ALVIN's support ship LULU, it was impossible to transit from Woods Hole Oceanographic Institution to the known outcrop area of Cashes Ledge in one day. At the prospects of losing one day of diving it was decided to dive on Mayo Swell which is a shorter distance away. Unfortunately, the entire area was covered with sediments and glacial erratics. No outcrops were located.

Dive #426

Location = Peck Ridge
42°50'N, 69°12'W

Date Conducted = 21 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: Seismic reflection profiles across Peck Ridge indicate that the basement surface may be exposed on the sea floor. A pre-dive survey using a 3.5 kHz transducer located a small pinnacle near to which a surface radar buoy was emplaced. Unfortunately, the surface controller vectored the submersible in the wrong direction and no outcrops were located.

Dive #427

Location = Isolated Peak along Fundy Fault Trend
43°23'N, 69°10'W

Date Conducted = 22 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: The submersible bottomed in an area having no apparent outcrops and headed on a course east of north. Within a short period of time it came across a series of rock terraces. ALVIN landed on top of the second terrace from which a sample was obtained (Figures 25 and 26). The outcrop which had a southeast dip of 45° and contained numerous vertical joints running east to west.

Description of Sample: One sample was collected which weighed 10.5 lbs (4.55 kgs). A photograph was taken of the outcrop (Figure 25) and of one or two samples being held by the mechanical arm (Figure 26). The depth of the outcrop was 85 m. with the radar buoy bearing 048° at 270 m. A thin section of the sample indicated a granitic composition with a texture common to a dike structure (Ballard, in preparation).

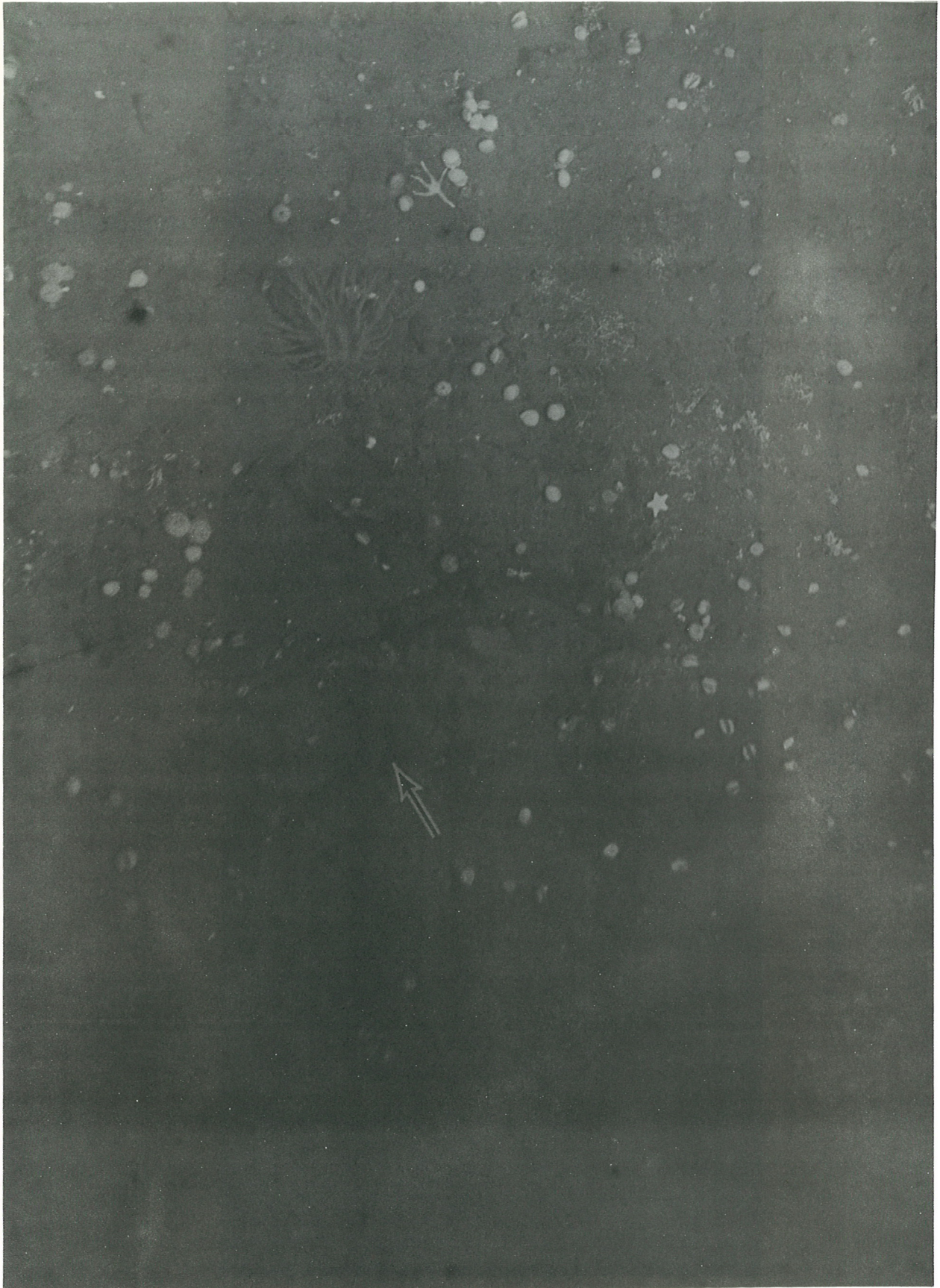


Figure 25. Arrow Points to Sample ALV-427-101 before Being Pried Loose and Collected by Mechanical Arm.

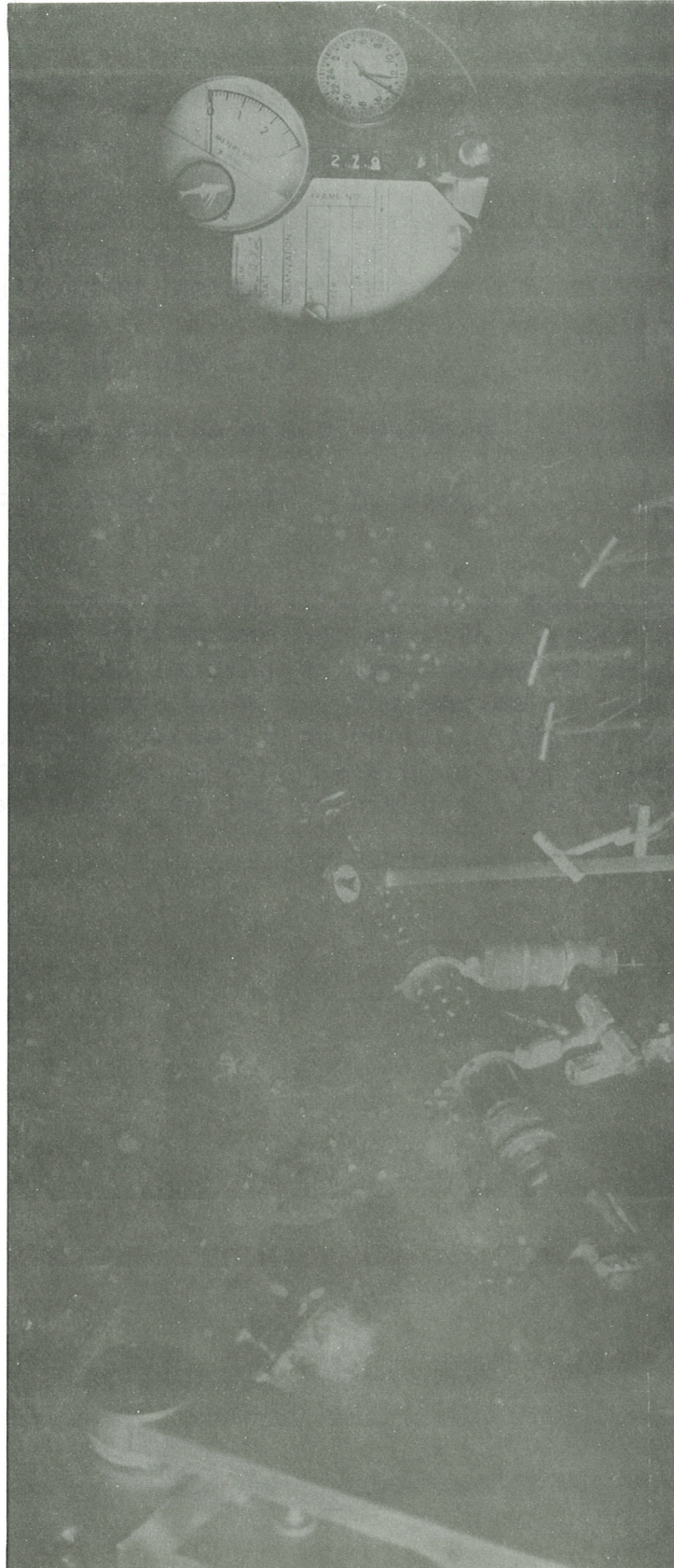


Figure 26. Sample ALV-427-1-1 Being Placed in Collection Bin by Mechanical Arm.

Dive #428

Location = South of Matinicus Rock
43°42.5'N, 68°48'W

Date Conducted = 23 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = L. King

Short Dive Description: An isolated pinnacle was located using the 3.5 kHz system and buoyed with a radar reflector. Within 15 minutes of landing on the bottom an outcrop was located at a depth of 95 m. . The strike of the exposure was NE-SW. The outcrop varied from vertical cliffs to low ridges to a flat surface(Figure 27). Several attempts were made to remove samples from a series of tight joints but none were recovered.

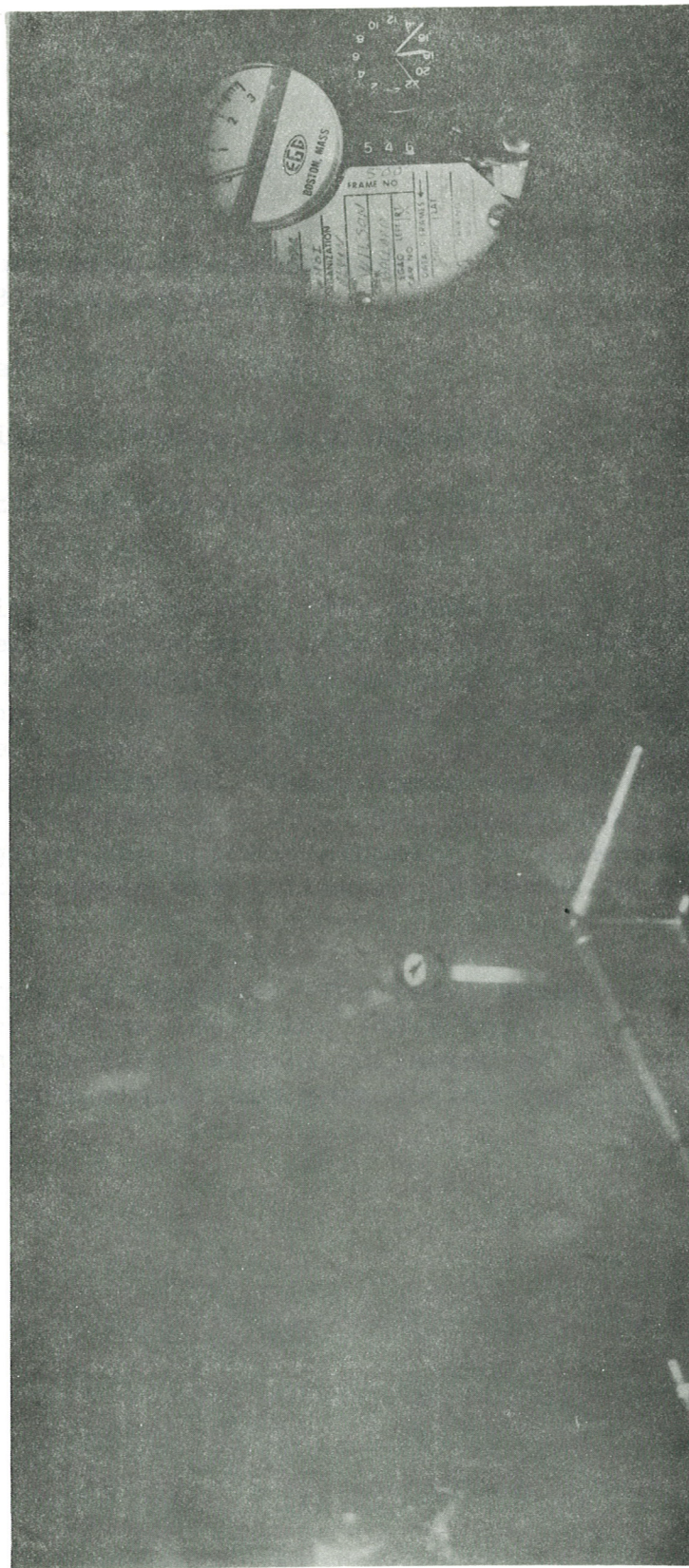


Figure 27. Photograph of Outcrop Surface Showing Parallel Trending Ridges.

Dive #429

Location = Just east of Cashes Ledge
43°02'N, 68°54'W

Date Conducted = 24 July 1972

Chief Scientist of Cruise = R.D. Ballard

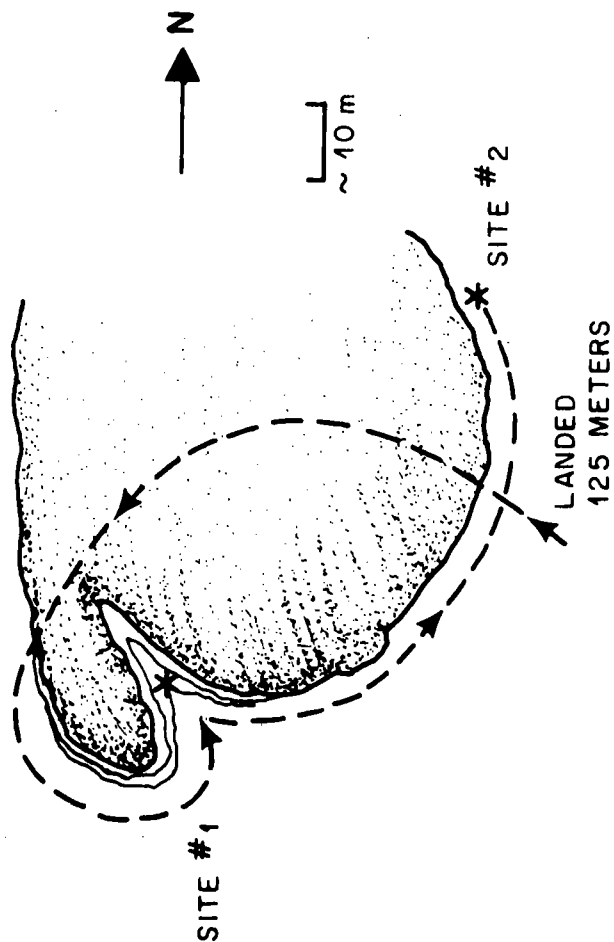
Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: The submersible landed on a sediment covered bottom at a depth of 125 m, drove in a N.W. direction, and acquired an outcrop within 15 minutes. ALVIN drove up on top of the outcrop, located a gully structure on its southern flank, flew off the outcrop, turned, and drove into the gully (Figure 28). Three large samples were collected at this site (Figures 28 & 29). The submersible then travelled along the edge of the outcrop stopping at a second site at which a fourth sample was collected (Figures 28 and 30).

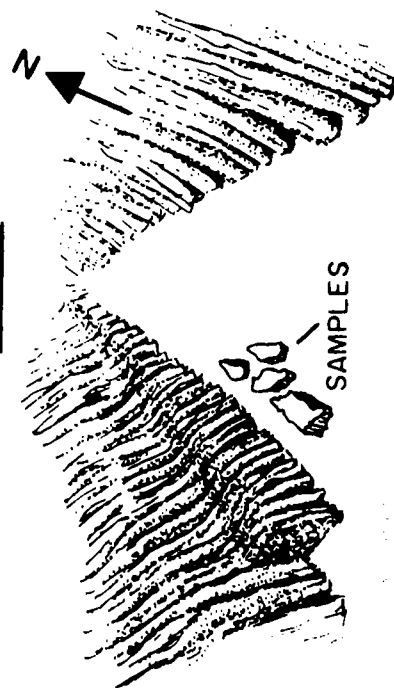
Description of Samples: The total weight of the four samples collected was 100.2 lbs (45.6 kgs). A thin section was made from the first sample collected at the first site and found to have a granitic composition (Ballard, in preparation).

DIVE #429

X-Y PROFILE



SITE #1



SITE #2

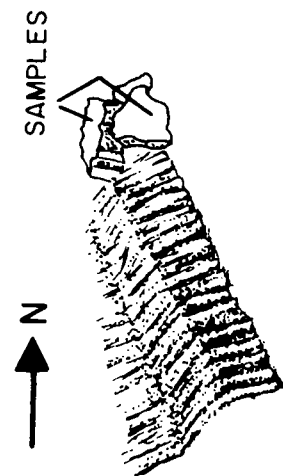


Figure 28. X-Y profile and artistic concept of outcrop surface and sample sites. Dashed line shows trace of submersible over bottom.



Figure 29. Arrows Show Location of Two of the Samples Collected at Site #1.



Figure 30. Photograph of Outcrop at Second Sample Site Where a Fourth Rock was Recovered.

Dive #430

Location = Cashes Ledge
43°01.1'N, 68°59.0'W

Date Conducted = 25 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: The vast majority of the dive was spent in frustration; at first attempting to locate an outcrop and then attempting to get representative samples. It wasn't until the end of the dive that a fractured portion of the outcrop was encountered from which three samples were obtained (Figure 31).

Description of Samples: Figure 31 shows the general nature of the outcrop which was samples. Figure 32 shows the second sample site. A total of three samples weighing 9.5 lbs (4.3 kgs) were collected from station #1 at a depth of 78 m. A thin section of Alv-430-2-1 (Figure 32) showed the rock to have a granitic composition (Ballard, in preparation).

Magnetics: The magnetic field intensity was measured at the sample site and found to be 56441.1 gammas.

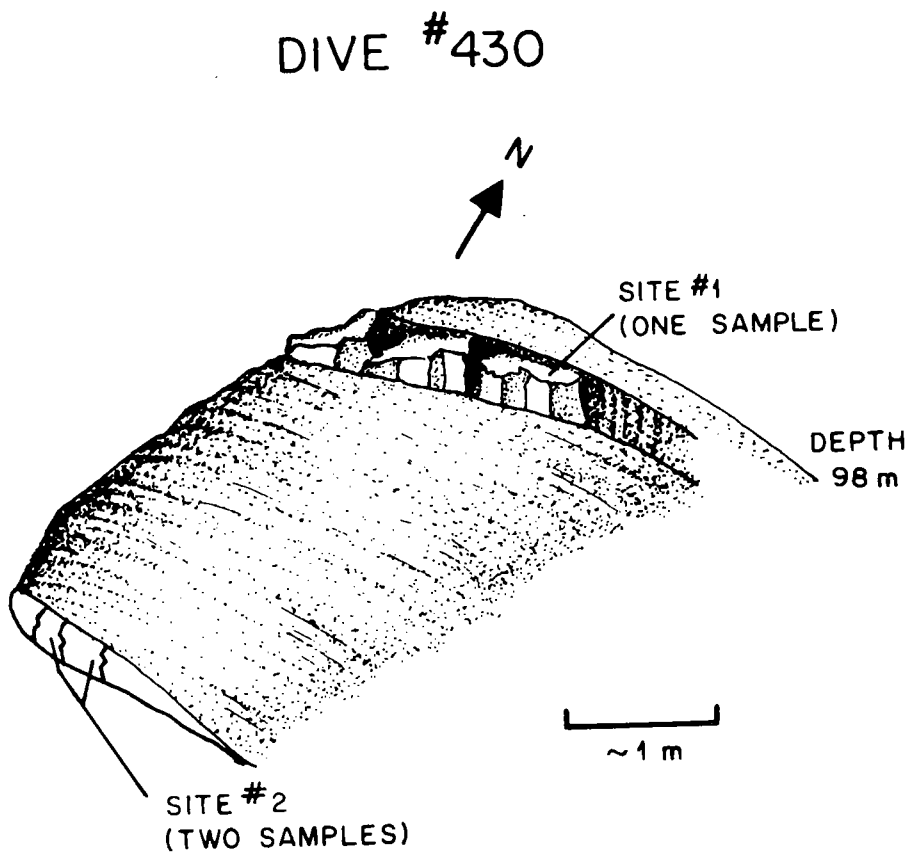


Figure 31. Nature of outcrop surface at sample sites 1 and 2.



Figure 32. Arrow Points to Sample Collected at Site #2.

Dive #431

Location = Southern Cashes Ledge
42°45.7'N, 68°53.8'W

Date Conducted = 26 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: The submersible landed on a sediment covered bottom at a depth of 88 m. and encountered an outcrop within 10 minutes. ALVIN rose up onto the outcrop, circled and landed at the first site at which one sample was collected (Figure 33). ALVIN then rose up and spent 5 hours inspecting the outcrop. The relief varied from a flat low-lying rock surface to step-like terraces to steep slopes cut by gullies. Near the end of the dive, the submersible landed at a second site (Figure 34) at which four additional samples were collected (depth 77 m.).

Description of Samples: A total of five samples were collected during the dive weighing 107.2 lbs (48.7 kgs). A thin section was made of Alv-431-2-4 and found to have a granitic composition (Ballard, in preparation).

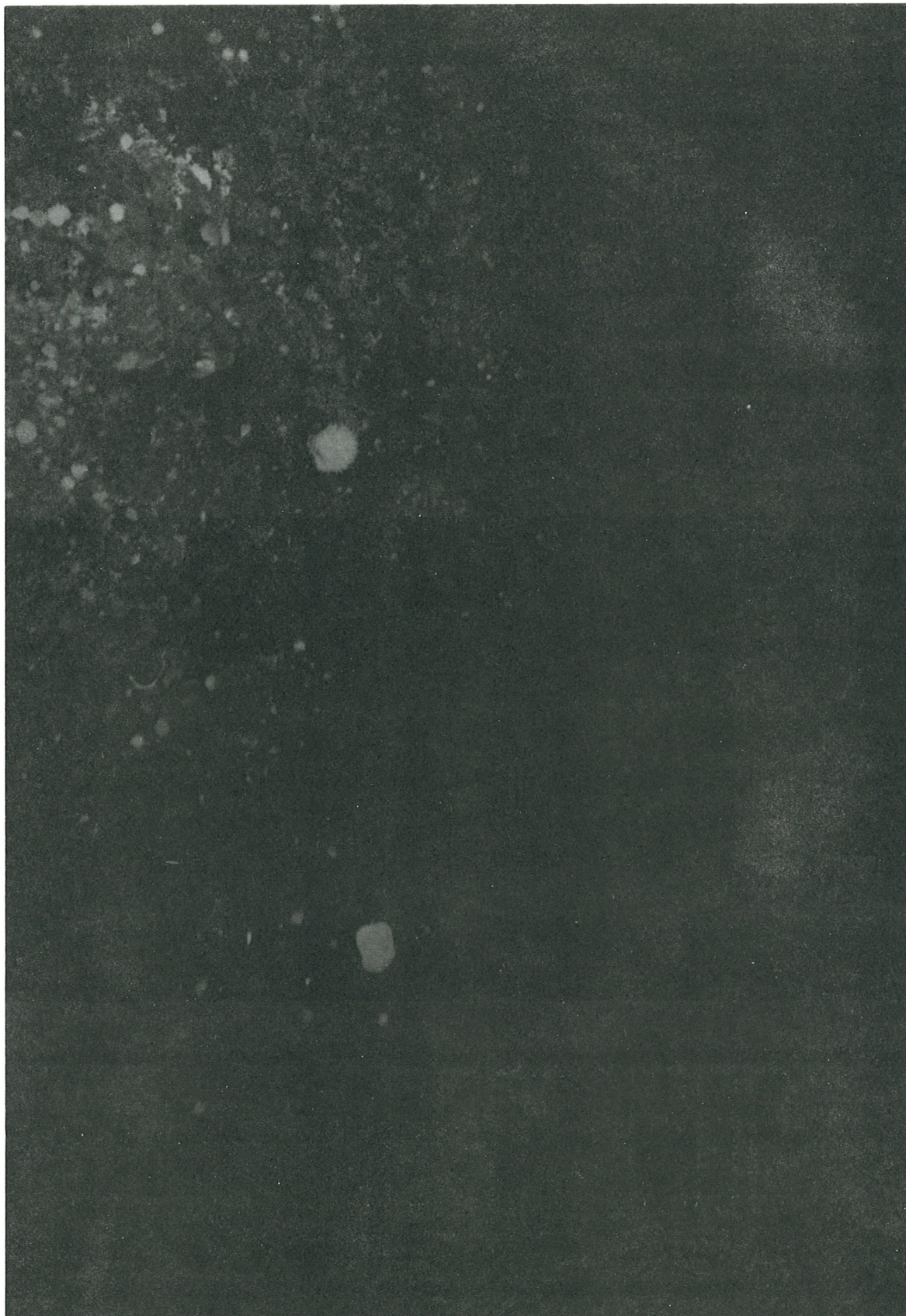


Figure 33. Arrow Shows Location of Sample ALV-431-1-1
at Site #1 Just After Rock was Removed.



Figure 34. Arrow Shows Location of Rock Fragments Which Were Collected at Site #2.

Dive #432

Location = Rodgers Swell
42°39.6'N, 68°40.9'W

Date Conducted = 27 July 1972

Chief Scientist of Cruise = R.D. Ballard

Senior Scientist Aboard ALVIN = R.D. Ballard

Short Dive Description: Upon reaching the bottom ALVIN traversed 450-650 m. across the sea floor to a large sand ridge. In making this traverse numerous low but well-defined ridges were encountered that trended E-W, were several feet in height, and had a wavelength between 30 and 40 m. Each ridge consisted of fine gravel at the crest with mud in the trough. Several extensive boulder fields were encountered but no outcrops were located (Figure 35).



Figure 35. Boulder Field of Glacial Erratics Forming One of a Series of Low-Lying Ridges on Top of Rodgers Swell.

Dives #442, 443, 444, 445, and 447

Location = Cashes Ledge
42°50'N, 68°55'W

Dates Conducted = 24-29 August 1972

Chief Scientist of Cruise = W. Bryan

Senior Scientists Aboard ALVIN = R.D. Ballard and W. Bryan

Cruise Summary: The purpose of the cruise on which these five dives were conducted was to field test a new computerized transponder navigation system in a simulated geologic mapping mission. Cashes Ledge was selected for this mission since it is the largest known bedrock feature within the center portion of the Gulf of Maine and since several successful sampling dives had already been conducted on it over the last two years.

R/V LULU transited to the area and conducted a limited echosounding survey to locate an isolated peak along the strike of the Ledge. Once located, a surface radar buoy was deployed for future reference (this buoy later broke loose and had to be re-deployed). A more extensive bathymetric survey was conducted using this radar reference and a preliminary bathymetric map constructed using this information and data collected previously by the U.S. Coast and Geodetic Survey (Figure 36a).

Following this survey two AMF bottom acoustic transponder were dropped on the sea floor and surveyed-in from LULU. This transponder net was then used to track the submersible during its traverses over the bottom. Since the net was not functioning properly on dive 442, a straza transponder was carried to the bottom by ALVIN on dive 443. Since during dive 443 both the straza and AMF systems functioned properly, the straza transponder was recovered at the end of the dive and only the AMF network was used for the remaining dives (444, 445, and 447).

ALVIN SURVEY OF BEDROCK PEAK ON CASHES LEDGE

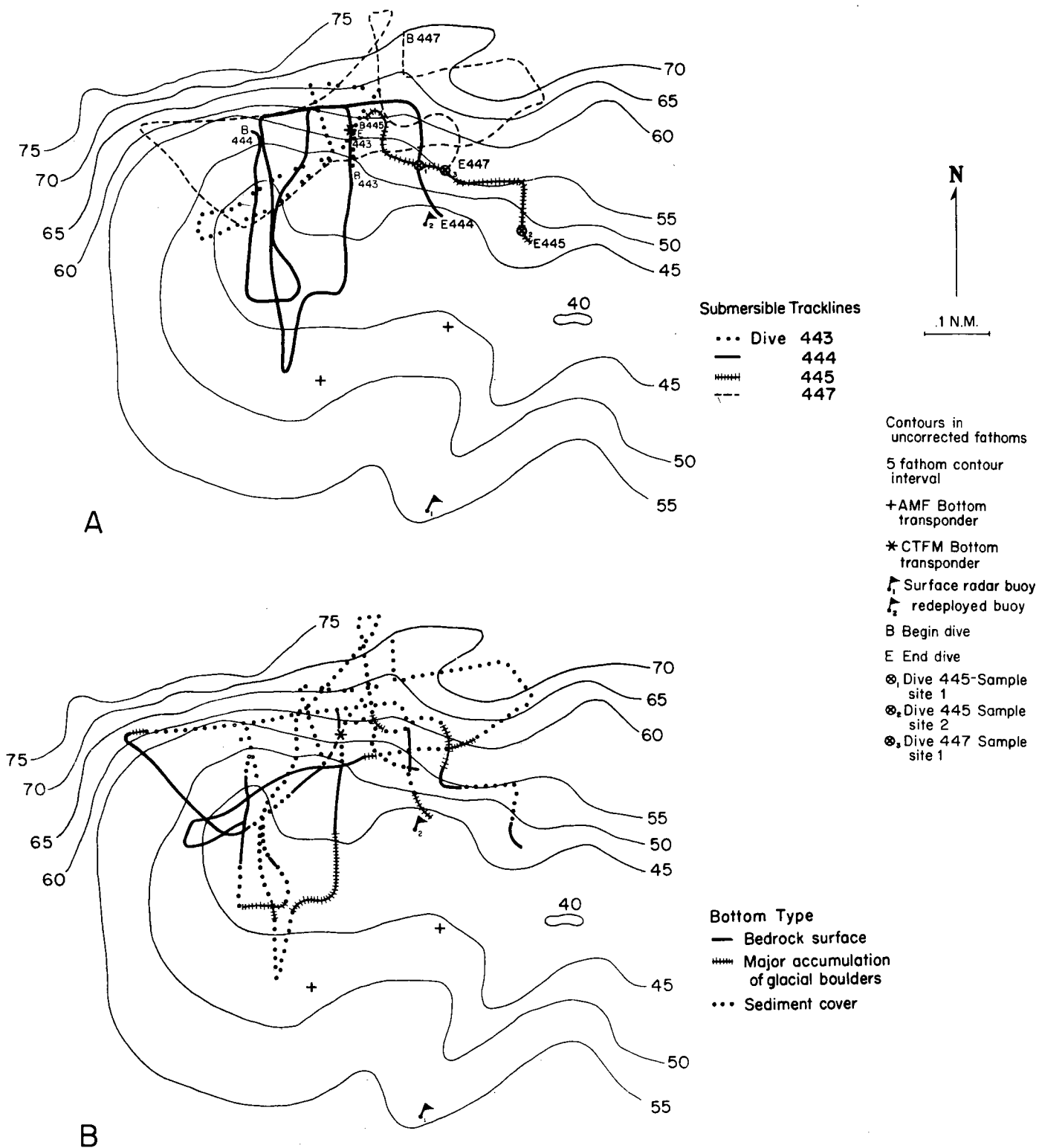


Figure 36. A: Submersible tracklines over outcrop on Cashes Ledge.

B: Nature of bottom types in outcrop area based upon submersible observations.

Over the next 6 days a series of 5 geologic dives were conducted during which the submersible made a series of traverses over the northwestern portion of this peak. Figure 36b is a map showing the distribution of these bottom types based upon visual and photographic observations made from the submersible. A more detailed discussion of these results can be found in Ballard (in preparation).

Description of Samples: During the course of this survey, the submersible stopped at three sites to collect bottom samples (Dives 445 and 447; figure 36a). A total of 8 samples were collected at dive 445 sample site #1, 9 at dive 445 sample site #2, and 1 at dive 447 sample site #1 (Figure 37). During dive 445 64.7 kg were collected, and 10.8 kg collected during dive 447. All were of a granitic composition (see Ballard, in preparation).



Figure 37. Arrow Points to Sample Collected on Dive 447
Prior to Being Picked Up By the Mechanical Arm.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the support given to this work. Of the five cruises conducted by ALVIN and its support ship R/V LULU, two were supported by the National Science Foundation under grant GD-32558, two were supported by the Department of Defense's Advanced Research Project Agency under grant N00014-71-C-0284, and one cruise was supported by the Office of Naval Research, code 466, under grant N00014-73-C-0097. Scientific support for much of the sea-going and laboratory work associated with the diving program, as well as complementary geophysical investigations aboard the R/V GOSNOLD, were provided by the National Science Foundation under grant GA-32454. The final analysis of the rock samples and their radiometric age dating was provided by the Institution's Ocean Industry Program, under grant 25/50.27.

LIST OF REFERENCES

- Ballard, R.D. (in preparation) The behavior of the Gulf of Maine and adjacent region during continental collision and subsequent separation: Ph.D. thesis submitted to University of Rhode Island, 1974.
- Ballard, R.D. (in preparation) Summary of seismic reflection, refraction, magnetic, and dredge station data collected during a geologic study of the Gulf of Maine: W.H.O.I. blue cover reference report.
- Ballard, R.D., and E. Uchupi (1972) Carboniferous and Triassic rifting: a preliminary outline of the tectonic history of the Gulf of Maine: Bull. Geol. Soc. Amer., v. 83, p. 2285-3202.
- Williams, D., and R. Davis (in preparation) A self contained deep sea rock drill: in A.E. Maxwell, Advanced marine technology, technical progress report, 1 Feb. 1973 - 31 July 1973, W.H.O.I. Ref. No. 73-92, p. 29-31.

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<p>Woods Hole Oceanographic Institution WHOI-74-29</p> <p>SUMMARY OF THE GEOLOGIC DIVES CONDUCTED IN THE GULF OF MAINE DURING 1971 and 1972 BY THE RESEARCH SUBMERSIBLE ALVIN by Robert D. Ballard. 73 pages. May 1974. Contract Nos. N00014-73-C-0097; NR 265-107, Department of Defense Research Project Agency contract N00014-71-C-0284; NR 293-008, National Science Foundation Grants GA-32454 and GD-32558.</p> <p>Detailed summary of geologic dives made by the submersible ALVIN in the Gulf of Maine. Report includes sampling procedures followed by the submersible, a listing and areal distribution of the samples collected, a comparison of the submersible to other sampling techniques, and the relationship of individual pilots to sampling success. Each dive is described in detail including representative bottom photographs and artist's concepts of outcrop regions.</p>	<p>1. Gulf of Maine</p> <p>2. ALVIN</p> <p>3. Geology</p> <p>I. Ballard, Robert D.</p> <p>II. N00014-73-C-0097; NR 265-107</p> <p>III. N00014-71-C-0284; NR 293-008</p> <p>IV. NSF GA-32454</p> <p>V. NSF GD-32558</p> <p>This card is UNCLASSIFIED</p>	<p>Woods Hole Oceanographic Institution WHOI-74-29</p> <p>SUMMARY OF THE GEOLOGIC DIVES CONDUCTED IN THE GULF OF MAINE DURING 1971 and 1972 BY THE RESEARCH SUBMERSIBLE ALVIN by Robert D. Ballard. 73 pages. May 1974. Contract Nos. N00014-73-C-0097; NR 265-107, Department of Defense Research Project Agency contract N00014-71-C-0284; NR 293-008, National Science Foundation Grants GA-32454 and GD-32558.</p> <p>Detailed summary of geologic dives made by the submersible ALVIN in the Gulf of Maine. Report includes sampling procedures followed by the submersible, a listing and areal distribution of the samples collected, a comparison of the submersible to other sampling techniques, and the relationship of individual pilots to sampling success. Each dive is described in detail including representative bottom photographs and artist's concepts of outcrop regions.</p>	<p>1. Gulf of Maine</p> <p>2. ALVIN</p> <p>3. Geology</p> <p>I. Ballard, Robert D.</p> <p>II. N00014-73-C-0097; NR 265-107</p> <p>III. N00014-71-C-0284; NR 293-008</p> <p>IV. NSF GA-32454</p> <p>V. NSF GD-32558</p> <p>This card is UNCLASSIFIED</p>
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